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Sample Assessment Materials
September 2007

GCE Chemistry

Edexcel Advanced Subsidiary GCE in Chemistry (8CH01)
First examination 2009

Edexcel Advanced GCE in Chemistry (9CH01)
First examination 2010

This specification includes e-Spec

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Contents

A Introduction

These sample assessment materials have been prepared to support the specification.

Their aim is to provide the candidates and centres with a general impression and flavour of the actual question papers and mark schemes in advance of the first operational examinations.

B Sample question papers

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	C	H	0	1	/	1	Signature	

Paper Reference(s)

6CH01/1

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Sample Assessment Material

Time: 1 hour 15 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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18	
19	
Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).
Do not use pencil. Use black or blue ink.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 19 questions in this question paper. The total mark for this paper is 80.
There are 28 pages in this question paper. Any blank pages are indicated.
Candidates may use a calculator.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 15(a), 16(d), 18(a)(iv), 18(b)(i) and 18(b)(ii). These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 25 minutes on this section. For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

Use the Periodic Table as a source of data.

1. Going across a period in the Periodic Table from left to right, the **general** trend is that

☒ **A** the bonding in the element itself changes from ionic to covalent

☒ **B** the number of neutrons in the nucleus increases

☒ **C** the first ionisation energy decreases

☒ **D** the metallic character increases

Q1

(Total 1 mark)

2. The electron configurations of argon, iron, chlorine and one other element are given below, but not in order. Which one represents the unnamed element?

☒ **A** $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$

☒ **B** $1s^2\,2s^2\,2p^6\,3s^2\,3p^6$

☒ **C** $1s^2\,2s^2\,2p^6\,3s^2\,3p^4$

☒ **D** $1s^2\,2s^2\,2p^6\,3s^2\,3p^5$

Q2

(Total 1 mark)

3. Buckminsterfullerene is a carbon molecule with formula C_{60} which can trap metal ions in its structure. Which of the following compounds of buckminsterfullerene would give a line of mass/charge ratio at 837.3 in a mass spectrometer?

☒ **A** Na_4C_{60}

☒ **B** K_3C_{60}

☒ **C** Ca_3C_{60}

☒ **D** AgC_{60}

Q3

(Total 1 mark)

Leave blank

4. This question is about the following equations:

A $Cu(NO_3)_2(s) \rightarrow CuO(s) + 2NO_2(g) + O_2(g)$

B $2HCl(aq) + CuO(s) \rightarrow H_2O(l) + CuCl_2(aq)$

C $C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

D $C_8H_{18}(l) + 8½O_2(g) \rightarrow 8CO(g) + 9H_2O(l)$

(a) Which equation is **not** balanced?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) Which equation shows incomplete combustion?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q4**

(Total 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

5. Which of the equations shown below represents the reaction for which ΔH is the standard enthalpy change of formation, $\Delta H^{\ominus}_{f\,298}$, for ethanol, C_2H_5OH. Ethanol melts at 156 K and boils at 352 K.

☒ **A** $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(g)$

☒ **B** $2C(s) + 3H_2(g) + O_2(g) \rightarrow C_2H_5OH(l)$

☒ **C** $2C(s) + 3H_2(g) + O(g) \rightarrow C_2H_5OH(g)$

☒ **D** $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

Q5

(Total 1 mark)

6. Use the data about four fuels given below to answer this question.

Fuel	Formula	Name	Enthalpy change of combustion /kJ mol^{-1}	Molar mass /g mol^{-1}
A	CH_4	methane	–890	16
B	CH_3OH	methanol	–726	32
C	C_3H_8	propane	–2219	44
D	C_4H_{10}	butane	–2877	58

(a) Which fuel, A, B, C or D, produces most energy per gram on complete combustion?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) Scientists give governments advice on technical issues. What information would scientists use when advising governments on the choice of one of these fuels, if the aim was to minimise carbon dioxide production?

☒ **A** mass of carbon per gram of fuel

☒ **B** mass of carbon per kilojoules produced

☒ **C** number of kilojoules produced per gram

☒ **D** number of kilojoules produced per mole

(1)

Q6

(Total 2 marks)

Leave blank

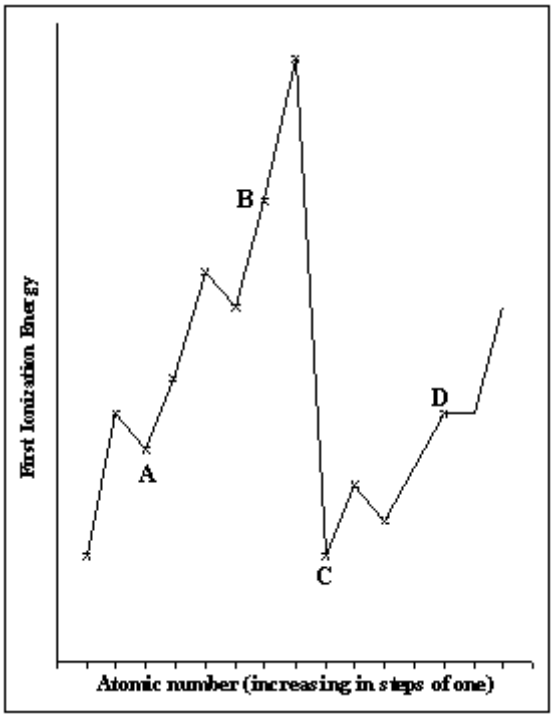
7. Which of the following equations represents the first ionisation of sulfur?

- ☒ **A** $S(s) + e^- \rightarrow S^-(g)$
- ☒ **B** $S(g) + e^- \rightarrow S^-(g)$
- ☒ **C** $S(s) \rightarrow S^+(g) + e^-$
- ☒ **D** $S(g) \rightarrow S^+(g) + e^-$

Q7

(Total 1 mark)

8. Which element marked on this graph is a halogen?



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

Q8

(Total 1 mark)

Leave blank

9. Question 9 is about the following ionisation energy sequences.

The values are all in kJ mol^{-1}.

A	1400	1000	950	830	700
B	420	3100	4400	5900	8000
C	1000	1250	1520	420	590
D	1520	2700	3900	5800	7200

Select from A to D the sequence which is most likely to represent the following:

(a) The first ionisation energies of five consecutive members of the same group in the Periodic Table, in order of increasing atomic number.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) The first five ionisation energies of an s-block element.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(c) The first five ionisation energies of a noble gas.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q9**

(Total 3 marks)

Leave blank

10. Question 10 is about four hydrocarbons with molecular formulae as shown.

A C_2H_2

B C_3H_6

C C_3H_8

D C_4H_{10}

(a) Which hydrocarbon has the same empirical formula as its molecular formula?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Use this space for any rough working. Anything you write in this space will gain no credit.

(b) Which has a molecular ion in the mass spectrum at mass/charge ratio = 58?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Leave blank

(c) Which is neither an alkane nor an alkene?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(d) Which could be 2-methylpropane?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

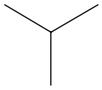
(1) **Q10**

(Total 4 marks)

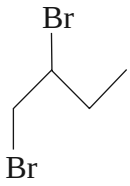
Leave blank

11. Question 11 is about the following organic compounds with skeletal formulae as shown:

A 

B 

C 

D 

(a) Which compound could be made from one of the others in an addition reaction?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

(b) Which compound has E–Z isomers?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q11**

(Total 2 marks)

12. Chemists investigating the mechanism of the reaction of ethene and bromine thought that the first step was the addition of Br^+. To test this, they reacted bromine with ethene in the presence of sodium chloride.

If their theory about the first step of the reaction was correct, which product might form as well as 1,2-dibromoethane?

☒ **A** CH_2BrCH_2Na

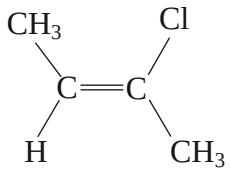
☒ **B** CH_2BrCH_2Cl

☒ **C** CH_2ClCH_2Cl

☒ **D** CH_2NaCH_2Na **Q12**

(Total 1 mark)

13. Which of the following is the correct name for the compound below?



☒ **A** Z-3-chlorobut-2-ene

☒ **B** E-3-chlorobut-2-ene

☒ **C** E-2-chlorobut-2-ene

☒ **D** Z-2-chlorobut-2-ene **Q13**

(Total 1 mark)

TOTAL FOR SECTION A: 21 MARKS

Leave blank

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

14. Copper(II) sulfate solution can be prepared from solid copper(II) carbonate by reaction with hot dilute sulfuric acid.

(a) Write the equation for the reaction, including state symbols.

(1)

(b) The experiment was carried out using 0.025 moles of sulfuric acid of concentration 2.0 mol dm^{-3}. What volume of this sulfuric acid was used?

(1)

(c) (i) It is usual to react the sulfuric acid with a slight excess of copper(II) carbonate.

Calculate the mass of copper(II) carbonate needed if a 10% excess is required.

[Molar mass of copper(II) carbonate = 123.5 g mol^{-1}]

(2)

Leave blank

(ii) A student doing this experiment chose to use a balance reading to 0.01 g in an attempt to work accurately.

Was this choice of balance necessary from the point of view of accuracy? Explain your answer.

.....

.....

(1)

(d) The sulfuric acid is heated to boiling and the copper(II) carbonate is added in small portions.

State the next step needed to prepare pure copper(II) sulfate solution. Justify your answer.

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.....

.....

(1)

(e) When the solution of copper(II) sulfate is allowed to crystallise, the crystals which are produced have the formula $CuSO_4.5H_2O$.

(i) What is the molar mass of $CuSO_4.5H_2O$?

(1)

(ii) 3.98 g of $CuSO_4.5H_2O$ crystals were obtained. Calculate the percentage yield in this experiment.

(2) **Q14**

(Total 9 marks)

Leave blank

15. This question is about magnesium and magnesium oxide.

*(a) Describe the bonding in magnesium and explain why it is a good conductor of electricity.

.....

.....

.....

.....

.....

.....

(3)

(b) Draw a diagram (using dots or crosses) for the ions in magnesium fluoride showing **all** the electrons and the ionic charges on:

(i) the magnesium ion

(1)

(ii) the fluoride ion.

(1)

(c) Under what conditions does magnesium fluoride conduct electricity?

Explain your answer.

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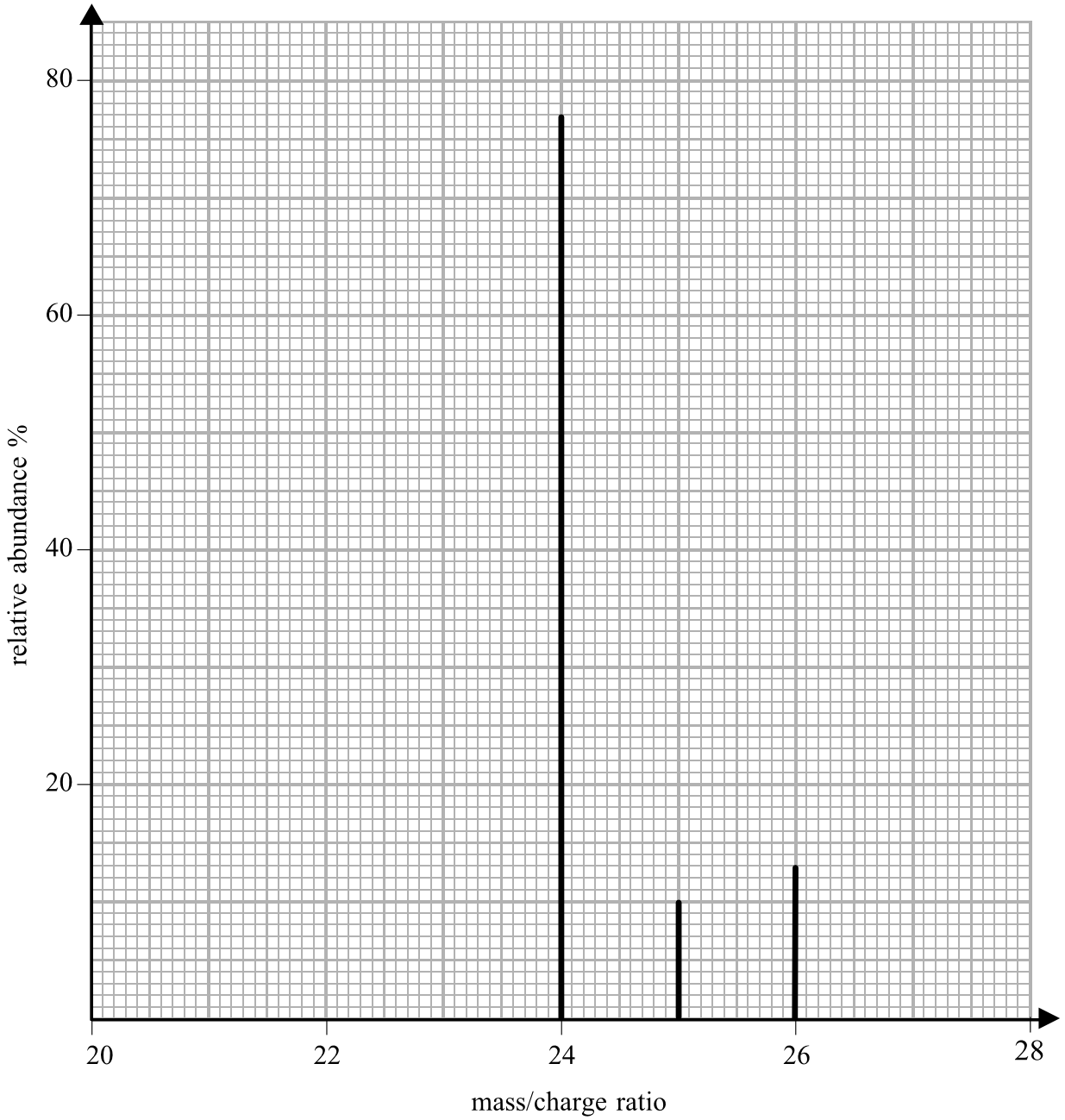
.....

(1)

Leave blank

(d) The mass spectrum of a sample of magnesium is shown below.



(i) Use the data above to estimate the percentage isotopic composition of the sample of magnesium. Hence calculate the average atomic mass of the sample of magnesium.

(2)

Leave blank

(ii) Why do the three isotopes have the same chemical properties?

.....

.....

(1)

(e) (i) Oceanographers studying plankton found that a sample of seawater contained 1.20 nanomol dm^{-3} of chlorophyll, $C_{55}H_{77}MgN_4O_5$. (1 nanomol = 1×10^{-9} mol)

What mass of magnesium would be present in 1.00 cm^3 of this sample of seawater? Give your answer to **three** significant figures.

(2)

(ii) X-ray diffraction can be used to locate atoms or ions in molecules like chlorophyll. X-rays are scattered by the electrons in atoms and ions. In chlorophyll the atoms of one of the elements still cannot be located with certainty by this technique.

Suggest which element is most difficult to locate.

.....

.....

(1)

Q15

(Total 12 marks)

Leave blank

16. Airbags, used as safety features in cars, contain sodium azide, NaN_3. An airbag requires a large volume of gas to be produced in a few milliseconds. The gas is produced in this reaction:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g) \qquad \Delta H \text{ is positive}$$

When the airbag is fully inflated, 50 dm^3 of nitrogen gas is produced.

(a) Calculate the number of molecules in 50 dm^3 of nitrogen gas under these conditions.

[The Avogadro constant = 6.02×10^{23} mol^{-1}. The molar volume of nitrogen gas under the conditions in the airbag is 24 dm^3 mol^{-1}].

(2)

(b) Calculate the mass of sodium azide, NaN_3, that would produce 50 dm^3 of nitrogen gas.

(3)

Leave blank

(c) What will happen to the temperature in the airbag when the reaction occurs?

.....

.....

(1)

*(d) The airbag must be strong enough not to burst in an accident. An airbag which has burst in an accident is hazardous if the sodium azide in it has decomposed.

Explain why this is so.

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(2)

Q16

(Total 8 marks)

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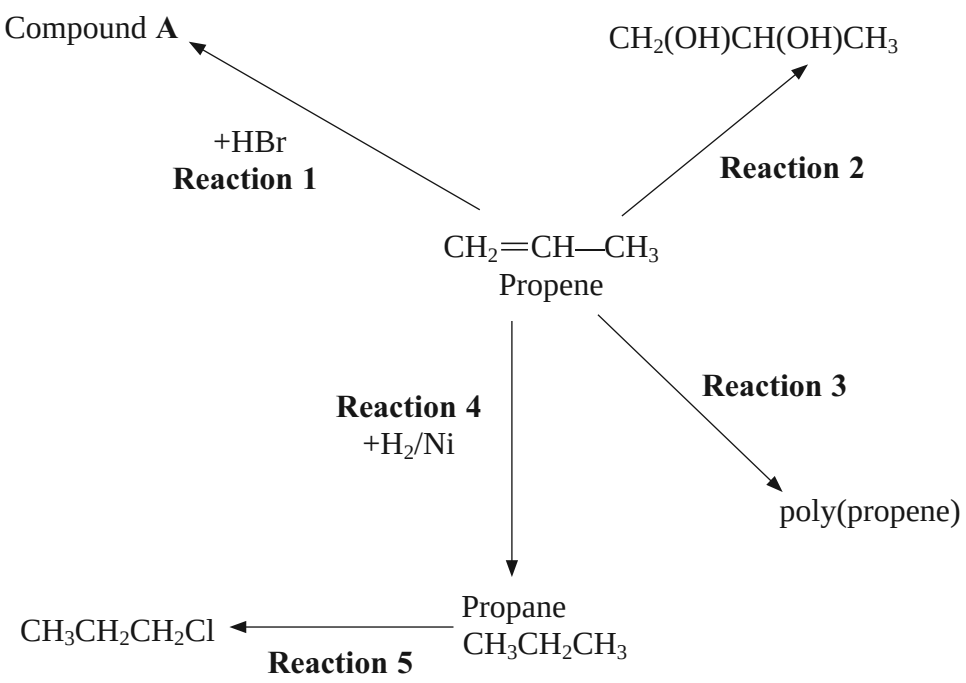
17. Propene can be used to make other important chemical products. The processes involved can be summarised in the diagram:



(a) (i) Give the mechanism for **Reaction 1.**

(3)

Leave blank

(ii) Explain why compound **A** and **not** its structural isomer is the major product in **Reaction 1**.

.....

.....

.....

(1)

(iii) Name compound **A** formed in **Reaction 1**.

Name .....

(1)

(b) What is added in **Reaction 2** to make the product $CH_2(OH)CH(OH)CH_3$?

.....

(1)

(c) Complete the balanced equation for the formation of poly(propene) in **Reaction 3** using **displayed** formulae.

$n(CH_2{=}CHCH_3) \rightarrow$

(2)

(d) Poly(propene) fibres can be used to make fleece which is used at several horse racing courses to prevent the ground becoming frozen.

State **one** advantage of using poly(propene) instead of natural fibres of similar cost.

.....

.....

(1)

Leave blank

(e) (i) One stage in the mechanism of **Reaction 5** is shown below.

$CH_3CH_2CH_3 + Cl^{\bullet} \rightarrow CH_3CH_2CH_2^{\bullet} + HCl$

What is this step?

.....

(1)

(ii) Give the name **or** formula of the trace product present in the final mixture which gives evidence for this mechanism.

.....

(1)

Q17

(Total 11 marks)

18. A student investigated a reaction which could be used to warm up coffee in self-heating cans.

$$Mg(s) + Cu(NO_3)_2(aq) \rightarrow Mg(NO_3)_2(aq) + Cu(s)$$

In the self-heating cans, the bottom has a compartment containing copper(II) nitrate solution. When a button on the bottom of the can is pressed, the magnesium powder is released into the compartment where it reacts with the copper(II) nitrate solution.

(a) A student investigated the enthalpy change for this reaction by measuring

$50.0\,cm^3$ of $0.300\,mol\,dm^{-3}$ copper(II) nitrate solution into a $100\,cm^3$ beaker and adding 1 g (an excess) of magnesium powder.

The results are shown below.

Temperature of copper(II) nitrate solution at start	=	22 °C
Temperature of mixture after reaction	=	43 °C

Leave blank

(i) Calculate the energy change which took place. The specific heat capacity of the solution is 4.20 J $g^{-1}K^{-1}$.

Which is the correct value for the energy change in joules?

(1)

(ii) How many moles of copper(II) nitrate were used in the experiment?

(1)

(iii) Calculate the enthalpy change for the reaction. You should include a sign and units in your answer.

(2)

Leave blank

*(iv) Suggest **two** changes you would make to **the equipment** used in order to improve the accuracy of the result.

.....

.....

.....

.....

(2)

(b) The ionic equation for the reaction is shown below:

$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$ $\Delta H = -532 \text{ kJ mol}^{-1}$

Would the following affect the value of the experimental result?

Explain your answer, stating the effect, if any, on the value of the enthalpy change obtained.

*(i) The student used 2 g rather than 1 g of magnesium.

.....

.....

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.....

(2)

*(ii) The heat losses that occurred from the student's beaker.

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.....

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(2)

Leave blank

(c) The temperature in the self-heating can needs to increase by 60 °C to produce a hot drink.

Suggest a change you could make to the mixture in the experiment in (a) to produce a greater temperature rise. You are **not** expected to do a calculation.

.....

.....

(1)

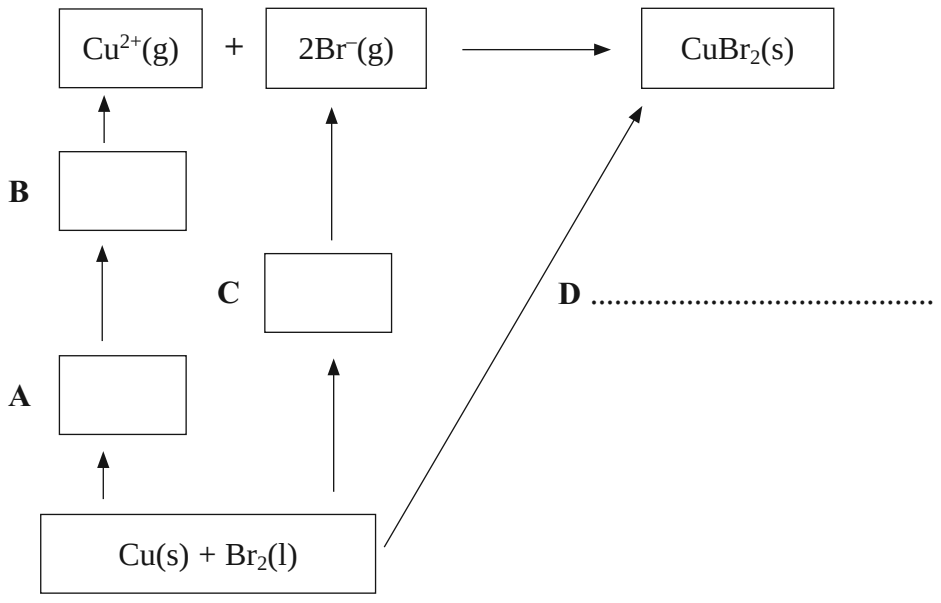
Q18

(Total 11 marks)

19. The following data can be used in a Born-Haber cycle for copper(II) bromide, $CuBr_2$.

Enthalpy change of atomisation of bromine $\Delta H^{\ominus}_{at}[\frac{1}{2}Br_{2(l)}]$	+111.9 kJ mol^{-1}
Enthalpy change of atomisation of copper, $\Delta H^{\ominus}_{at}[Cu(s)]$	+338.3 kJ mol^{-1}
First ionisation energy of copper, E_{m1} [Cu(g)]	+746.0 kJ mol^{-1}
Second ionisation energy of copper, E_{m2} [Cu(g)]	+1958.0 kJ mol^{-1}
Electron affinity of bromine, E_{aff}[Br(g)]	–342.6 kJ mol^{-1}
Enthalpy change of formation of $CuBr_2$(s), $\Delta H_f^{\ominus}$ [$CuBr_2$(s)]	–141.8 kJ mol^{-1}

(a) On the following outline of a Born-Haber cycle complete the boxes **A**, **B**, and **C** by putting in the formula and state symbol for the appropriate species and writing the name of the enthalpy change **D**.



(3)

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(b) Use the data to calculate a value for the lattice energy of copper(II) bromide.

Give a sign and units in your answer.

(3)

(c) When the lattice energy of copper(II) bromide is calculated from ionic radii and charges, the result is a value numerically about 10% less than the one obtained from the Born-Haber cycle.

(i) What does this suggest about the nature of the bonding in copper(II) bromide?

.....

.....

(1)

(ii) Draw a diagram to show how the smaller copper ion alters the shape of the larger bromide ion.

(1) **Q19**

(Total 8 marks)

TOTAL FOR SECTION B: 59 MARKS
TOTAL FOR PAPER: 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lathanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	C	H	0	2	/	1	Signature	

Paper Reference(s)

6CH02/1

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Sample Assessment Material

Time: 1 hour 15 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
Section A	
Section B	
Section C	
Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature. Check that you have the correct question paper. Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).
Do not use pencil. Use black or blue ink.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 28 questions in this question paper. The total mark for this paper is 80.
There are 28 pages in this question paper. Any blank pages are indicated.
Candidates may use a calculator.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 26(b)(ii), 27(a)(vi), 27(b), 28(b)(i), 28(b)(iv) and 28(b). These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 30 minutes on this section. Put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

Each of the questions or incomplete statements is followed by four suggested answers. Select the BEST answer in each case.

1. Which of the following best describes the molecular shape of carbon dioxide, CO_2?

☒ **A** linear

☒ **B** trigonal planar

☒ **C** triangular

☒ **D** v-shaped

Q1

(Total 1 mark)

2. Which of the following species is polar?

☒ **A** NH_3

☒ **B** BF_3

☒ **C** SO_3

☒ **D** CO_3^{2-}

Q2

(Total 1 mark)

3. Polar liquids are affected by electric fields. For which of the following liquids would a jet of the liquid be affected by an electric field?

☒ **A** hexane

☒ **B** cyclohexane

☒ **C** cyclohexene

☒ **D** cyclohexanol

Q3

(Total 1 mark)

Leave blank

4. What are the intermolecular forces in methanal, HCHO?

- ☒ **A** London forces only
- ☒ **B** hydrogen bonds and London forces
- ☒ **C** permanent dipole – permanent dipole only
- ☒ **D** permanent dipole – permanent dipole and London forces

Q4

(Total 1 mark)

5. Which of the following substances is likely to be insoluble in water?

- ☒ **A** methanol, CH_3OH
- ☒ **B** ethanol, CH_3CH_2OH
- ☒ **C** fluoromethane, CH_3F
- ☒ **D** hydrogen fluoride, HF

Q5

(Total 1 mark)

6. The following liquids have a similar number of electrons per molecule. Suggest which is likely to have the highest boiling point?

- ☒ **A** $CH_3CH_2CH_2CH_2CH_3$
- ☒ **B** $(CH_3)_3COH$
- ☒ **C** $CH_3CH_2CH(OH)CH_3$
- ☒ **D** $CH_3CH_2CH_2CH_2OH$

Q6

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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7. Which concentrated acid should be used to dissolve a carbonate of a Group 2 metal to carry out a flame test?

☒ **A** ethanoic acid

☒ **B** hydrochloric acid

☒ **C** nitric acid

☒ **D** sulfuric acid

Q7

(Total 1 mark)

8. What colour does a barium salt give in a flame test?

☒ **A** colourless

☒ **B** green

☒ **C** red

☒ **D** yellow-red

Q8

(Total 1 mark)

9. Separate flame tests are carried out with lithium, sodium, potassium, magnesium, calcium and strontium salts. How many of these metal ions would colour the flame red?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

Q9

(Total 1 mark)

Leave blank

10. A Group 2 element reacts vigorously with water to produce a soluble hydroxide, which forms a white precipitate when neutralised by sulfuric acid and forms a carbonate which is very stable to heat. The element could be

- ☒ **A** magnesium
- ☒ **B** calcium
- ☒ **C** strontium
- ☒ **D** barium

Q10

(Total 1 mark)

11. The Group 2 metals, considered in order of increasing atomic number, show a **decrease** in

- ☒ **A** first ionisation energy
- ☒ **B** nuclear charge
- ☒ **C** chemical reactivity
- ☒ **D** ionic radius

Q11

(Total 1 mark)

12. When a Group 1 metal nitrate is heated, brown fumes are observed. The metal could be

- ☒ **A** lithium
- ☒ **B** sodium
- ☒ **C** rubidium
- ☒ **D** caesium

Q12

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

13. Methyl orange is red in acidic solutions and yellow in alkaline solutions. What is the colour of the indicator at the end point of a titration of aqueous sodium hydroxide solution with hydrochloric acid?

- ☒ **A** red
- ☒ **B** pink
- ☒ **C** orange
- ☒ **D** yellow

Q13

(Total 1 mark)

14. The volume, in cm^3, of 0.25 mol dm^{-3} hydrochloric acid required to neutralise 100 cm^3 of 0.125 mol dm^{-3} barium hydroxide solution, $Ba(OH)_2(aq)$, is

- ☒ **A** 25
- ☒ **B** 50
- ☒ **C** 100
- ☒ **D** 200

Q14

(Total 1 mark)

15. What is the oxidation number of **sulfur** in sodium tetrathionate, $Na_2S_4O_6$?

- ☒ **A** –½
- ☒ **B** +1½
- ☒ **C** +2½
- ☒ **D** +5

Q15

(Total 1 mark)

Leave blank

16. Which of the following statements is FALSE?

☒ **A** iodine is more electronegative than bromine.

☒ **B** fluorine is more electronegative than chlorine.

☒ **C** metallic elements tend to react by loss of electrons.

☒ **D** chlorine is more electronegative than sulfur.

Q16

(Total 1 mark)

17. A commercial production of iodine involves the reduction of a solution of iodate(V) ions, IO_3^-, with hydrogen sulfite ions, HSO_3^-. The equation for the reaction may be written

$$xIO_3^- + yHSO_3^- \longrightarrow zSO_4^{2-} + I_2 + 3H^+ + H_2O$$

What are the balancing numbers x, y and z?

☒ **A** 5,2,2

☒ **B** 2,5,2

☒ **C** 2,5,5

☒ **D** 5,5,2

Q17

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

18. An organic compound is found to react with sodium metal and to react with acidified sodium dichromate(VI), but not to decolourise bromine water, nor to neutralise sodium carbonate solution. The liquid could be

- ☒ **A** ethanol
- ☒ **B** ethane
- ☒ **C** ethanoic acid
- ☒ **D** ethene

Q18

(Total 1 mark)

19. Which of the following is **not** a greenhouse gas?

- ☒ **A** CH_4
- ☒ **B** CO_2
- ☒ **C** H_2O
- ☒ **D** N_2

Q19

(Total 1 mark)

20. Which of the following fuels has the smallest carbon footprint?

- ☒ **A** petrol made from crude oil
- ☒ **B** hydrogen made from methane
- ☒ **C** ethanol made from sugar
- ☒ **D** coal

Q20

(Total 1 mark)

21. Which of the following would **not** lead to a greater sustainability in an industrial process?

- ☒ **A** using a catalyst that improves atom economy
- ☒ **B** running the reaction at a higher temperature
- ☒ **C** using biofuels to run the process
- ☒ **D** recycling waste products

Q21

(Total 1 mark)

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The following questions deal with situations. Each situation is followed by a set of questions. Select the best answer for each question.

22. This question concerns the preparation of 1-bromobutane from butan-1-ol, 50% sulfuric acid and sodium bromide. The mixture was placed in a flask and heated under reflux for ten minutes.

	Boiling temperature / °C
1-bromobutane	100
butan-1-ol	118

(a) The reason that 50% sulfuric acid was used rather than concentrated sulfuric acid is because concentrated sulfuric acid

☒ **A** would oxidise some of the bromide ions to bromine.

☒ **B** would cause the reaction to go too fast.

☒ **C** would react with the bromide ions to produce hydrogen bromide.

☒ **D** is too hazardous a chemical.

(1)

(b) The reaction mixture was distilled. The impure distillate did **not** contain

☒ **A** butan-1-ol

☒ **B** 1-bromobutane

☒ **C** sodium bromide

☒ **D** hydrogen bromide

(1)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

(c) The impure 1-bromobutane was washed with concentrated hydrochloric acid and shaken in a tap funnel with a base to remove acidic impurities. Which of the following would remove acidic impurities without reacting with the 1-bromobutane.

☒ **A** calcium hydroxide solution

☒ **B** sodium hydroxide solution

☒ **C** calcium chloride solution

☒ **D** sodium hydrogencarbonate solution

(1)

(d) The 1-bromobutane was washed with water, dried and distilled. Which of the following is the correct procedure?

☒ **A** heat the liquid to 118 °C and collect the substance given off

☒ **B** heat the liquid to 100 °C and collect the substance given off

☒ **C** boil the liquid and collect the fraction that boils off between 116 and 120 °C

☒ **D** boil the liquid and collect the fraction that boils off between 98 and 102 °C

(1)

Q22

(Total 4 marks)

Leave blank

23. Almost two thirds of the world's ethanoic acid is made using the following equilibrium reaction, with the aid of an iridium complex as a catalyst.

$$CH_3OH(l) + CO(g) \rightleftharpoons CH_3COOH(l) \quad \Delta H = -135\ kJ\ mol^{-1}$$

Which of the following changes in conditions would increase the equilibrium yield of ethanoic acid?

☒ **A** increase pressure

☒ **B** decrease pressure

☒ **C** increase temperature

☒ **D** add a catalyst

Q23

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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24. Some absorptions by chemical bonds in the infrared spectrum are given below.

A O—H stretching in alcohols at 3750–3200 cm^{-1}

B C—H stretching in alkanes at 2962–2853 cm^{-1}

C C═O stretching in aldehydes at 1740–1725 cm^{-1}

D C═O stretching in ketones at 1700–1680 cm^{-1}

From A–D above, select which feature of the infrared spectrum would enable you to distinguish between the following compounds:

propanone, CH_3COCH_3, propanal, CH_3CH_2CHO

propan-1-ol, $CH_3CH_2CH_2OH$

(a) propanone from propanal and propan-1-ol

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) propanal from propanone and propan-1-ol

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Leave blank

(c) propan-1-ol from propanal and propanone

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q24**

(Total 3 marks)

TOTAL FOR SECTION A: 29 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

25. This question is about organic compounds with the molecular formula C_3H_8O.

(a) Draw the structural formulae of the two isomers with molecular formula C_3H_8O which are alcohols. Give the names of these alcohols.

	Alcohol 1	**Alcohol 2**
Structural formula		
Name	…….	…….

(4)

(b) Primary alcohols can be oxidised to carboxylic acids.

(i) Give the name and structural formula of the carboxylic acid formed when the primary alcohol C_3H_8O is fully oxidised.

Name .....

Structural formula

(2)

(ii) State the reagents used for this oxidation.

Reagent 1 .....

Reagent 2 .....

(2) **Q25**

(Total 8 marks)

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26. (a) (i) Name the type of bonding that exists between water molecules.

.....

(1)

(ii) Draw a diagram to show this bonding. Use displayed formulae of two water molecules. Clearly mark and label the bond angle **between** the water molecules.

(2)

(b) (i) Draw the boron trichloride molecule, BCl_3, making its shape clear. Mark the bond angle on your diagram.

(2)

*(ii) Explain why boron trichloride has this shape.

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(3)

Leave blank

(iii) Explain why a B–Cl bond is polar.

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(1)

(iv) Explain why a BCl_3 molecule is non-polar.

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(1)

(v) Name the strongest intermolecular force between boron trichloride molecules.

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(1)

Q26

(Total 11 marks)

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27. (a) This part of the question is about the hydrolysis of halogenoalkanes.

$2\ cm^3$ of ethanol is added to each of three separate test-tubes.

Three drops of 1-chlorobutane are added to the first, three drops of 1-bromobutane to the second, and three drops of 1-iodobutane are added to the third test-tube.

$2\ cm^3$ portions of hot aqueous silver nitrate solution are added to each test-tube.

A precipitate forms immediately in the third test-tube, slowly in the second test-tube and extremely slowly in the first test-tube. In each reaction the precipitate is formed by silver ions, $Ag^+(aq)$, reacting with halide ions formed by hydrolysis of the halogenoalkane.

(i) Why was ethanol added to each test-tube?

.....

(1)

(ii) The mechanism of this reaction is similar to that of the reaction between halogenoalkanes and aqueous hydroxide ions.

What feature of a water molecule enables it to act as a nucleophile in this reaction? Suggest the mechanism for the reaction between water and 1-iodobutane. (You may represent 1-iodobutane as RCH_2I).

Feature of water molecule

.....

.....

Mechanism

(4)

Leave blank

(iii) What is the colour of the precipitate in the third test-tube?

.....

(1)

(iv) Name the precipitate which forms slowly in the **first** test-tube.

.....

(1)

(v) Ammonia solution is added to the precipitate in the **first** test-tube. Describe what you would observe.

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(1)

*(vi) Suggest, why the rates of hydrolysis of the three halogenoalkanes are different, in terms of bonding and kinetics.

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(3)

Leave blank

*(b) One method of the manufacture of alcohols is to react steam with an alkene.
For example

$$C_2H_4(g) + H_2O(g) \longrightarrow C_2H_5OH(l)$$

Suggest TWO reasons why this method is preferred to the hydrolysis of halogenoalkanes.

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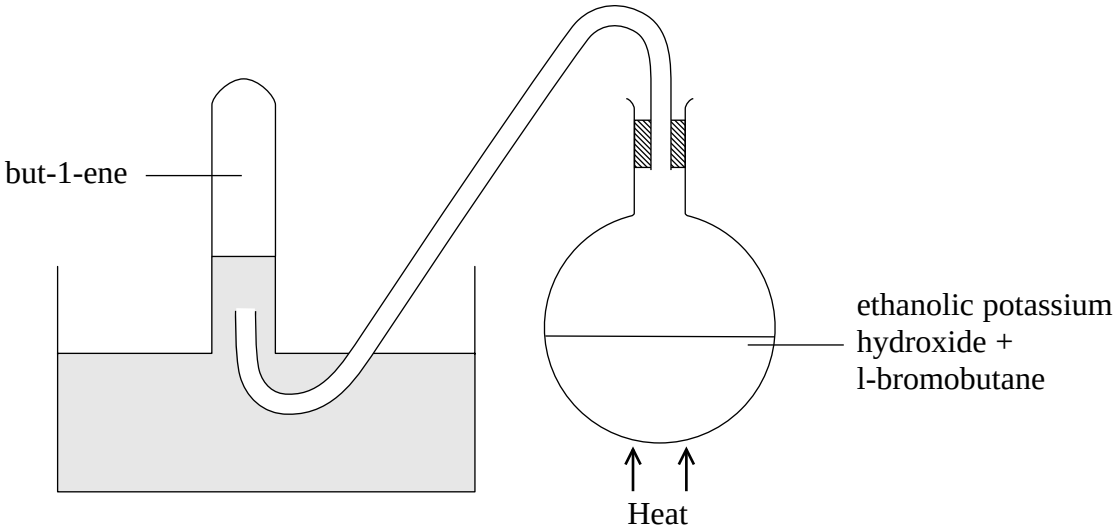
.....

(2)

(c) 1-bromobutane reacts with an ethanolic solution of potassium hydroxide on heating to form but-1-ene. A diagram of the apparatus that could be used to carry out this reaction and to collect the gaseous but-1-ene is shown below.



(i) State the hazard when the heating is stopped.

.....

.....

(1)

(ii) How would you minimise the risk associated with this hazard?

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.....

(1)

Q27

(Total 15 marks)

TOTAL FOR SECTION B: 34 MARKS

Leave blank

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

28. Chlorine was used in swimming pools as a bactericide.

The amount of chlorine present can be determined by adding excess potassium iodide solution to a known volume of swimming pool water. This reacts to form iodine:

$$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$$

The amount of iodine formed is then found by titration with sodium thiosulfate solution of known concentration.

The ionic equation for the reaction between iodine and sodium thiosulfate in aqueous solution is

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

A student carried out the determination of chlorine in a sample of swimming pool water. A record of the measurements obtained is given below:

Volume of water sample tested = 1000 cm^3

Final reading of burette = 16.3 cm^3

Initial reading of burette = 7 cm^3

Volume added from burette = 9.3 cm^3

Concentration of sodium thiosulfate solution = 0.00500 mol dm^{-1}

(a) (i) The record of measurements reveals faults both in the procedure and the recording of measurements. State **one** fault in each of these.

Procedure .....

Recording of measurements .....

.....

(2)

(ii) Calculate the number of moles of sodium thiosulfate used in the titration.

(1)

Leave blank

(iii) Use your answer to (ii) to calculate the number of moles of iodine which reacted.

(1)

(iv) Deduce the concentration of chlorine, in mol dm^{-3}, in the swimming pool water.

(1)

(b) The disinfecting action of chlorine in swimming pools is due to the presence of chloric(I) acid, HClO, formed by the reaction of chlorine with water.

In many swimming pools, chemicals other than chlorine are used to form chloric(I) acid. This is partly because the use of chlorine gas causes much more corrosion of metal parts in swimming pools than does chloric(I) acid.

Compounds used to chlorinate swimming pool water in this way include calcium chlorate(I) and chlorine dioxide.

*(i) State and explain the type of reaction that occurs when chlorine attacks a metal, using the example of iron.

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.....

(2)

(ii) Suggest **one** other reason why the use of chlorine is undesirable in swimming pools.

.....

(1)

(iii) Give the formula for calcium chlorate(I).

.....

(1)

Leave blank

*(iv) Chlorine dioxide, ClO_2, undergoes a disproportionation reaction when it reacts with water.

$$4ClO_2 + 2H_2O \rightarrow HClO + 3HClO_3$$

Explain, in terms of oxidation numbers, why this is a disproportionation reaction.

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(2)

*(c) Discuss and explain the science community's advice that CFCs should no longer be used in aerosols, foams and refrigerants. Support your answer with one or more equations.

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(6)

Q28

(Total 17 marks)

TOTAL FOR SECTION C: 17 MARKS
TOTAL FOR PAPER: 80 MARKS

END

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18)
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	4.0 He helium 2
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 38	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lathanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	C	H	0	4	/	1	Signature	

Paper Reference(s)

6CH04/1

Edexcel GCE

Chemistry

Advanced

Unit 4: General Principles of Chemistry I – Rate, Equilibria and Further Organic Chemistry (including synoptic assessment)

Sample Assessment Material

Time: 1 hour 40 minutes

Materials required for examination
Data Booklet

Items included with question papers
Nil

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Total	

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature. Check that you have the correct question paper. Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).
Do not use pencil. Use black or blue ink.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 20 questions in this question paper. The total mark for this paper is 90.
There are 32 pages in this question paper. Any blank pages are indicated.
Candidates may use a calculator.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 16(d), 17(b), 18(c)(ii), 19, 20(b)(i) and 20(b)(iii). These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 30 minutes on this section. For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

1. This question involves the following techniques which can be used to follow chemical reactions in order to investigate their kinetics.

A collecting and measuring the volume of a gas

B colorimetry

C measuring the electrical conductivity

D titration with standard acid solution

Select, from A to D, the technique **most** appropriate to investigate:

(a) the hydrolysis of 1-bromobutane using hydroxide ions

$$C_4H_9Br(l) + OH^-(aq) \rightarrow C_4H_9OH(l) + Br^-(aq)$$

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) the decomposition of the benzenediazonium ion

$$C_6H_5N_2^+(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + H^+(aq)$$

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Leave blank

(c) the reaction of acidified potassium manganate(VII) with propan-2-ol to give propanone and manganese(II) sulfate.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(d) the catalytic decomposition of hydrogen peroxide.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Q1

(Total 4 mark)

Leave blank

2. 1,2-dibromoethane reacts with potassium iodide dissolved in methanol according to the equation:

$$C_2H_4Br_2 + 2KI \rightarrow C_2H_4 + 2KBr + I_2$$

The rate equation for this reaction is

☒ **A** rate = $k[KI]^2[C_2H_4Br_2]$

☒ **B** rate = $k[KI]^2$

☒ **C** rate = $k[C_2H_4Br_2]$

☒ **D** not possible to deduce from this information

Q2

(Total 1 mark)

3. For the reaction between sodium bromate(V) and sodium bromide in acidic solution, the rate equation is:

$$\text{Rate} = k[BrO_3^-][Br^-][H^+]^2$$

When the concentrations of all three reactants are doubled, the rate will increase by a factor of

☒ **A** 4

☒ **B** 6

☒ **C** 8

☒ **D** 16

Q3

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

4. This question refers to the following reaction at 298 K:

$$N_2O_4(g) \rightarrow 2NO_2(g) \qquad \Delta H = +57.2 \text{ kJ mol}^{-1}$$

	S /J mol^{-1}K^{-1}
$N_2O_4(g)$	304.2
$NO_2(g)$	240.0

(a) Calculate ΔS_{system}, in J mol^{-1} K^{-1}, for this reaction.

☒ **A** –175.8

☒ **B** +175.8

☒ **C** –64.2

☒ **D** +64.2

(1)

(b) Calculate $\Delta S_{surroundings}$, in J mol^{-1} K^{-1}, for this reaction at 298 K.

☒ **A** –192

☒ **B** +192

☒ **C** –0.192

☒ **D** +0.192

(1) **Q4**

(Total 2 marks)

5. For the equilibrium,

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which is the correct expression for K_p?

☒ **A** $\dfrac{[NH_3(g)]^2}{[N_2(g)][H_2(g)]^3}$

☒ **B** $\dfrac{P_{N_2(g)}P_{H_2(g)}}{P_{NH_3(g)}}$

☒ **C** $\dfrac{P^2_{NH_3(g)}}{P_{N_2(g)}P^3_{H_2(g)}}$

☒ **D** $\dfrac{P_{N_2(g)}P^3_{H_2(g)}}{P^2_{NH_3(g)}}$

Q5

(Total 1 mark)

Leave blank

6. The expression for K_c for the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is

$$K_c = \frac{[SO_3(g)]^2}{[SO_2(g)]^2[O_2(g)]}$$

What are the units of K_c in this equilibrium expression?

- ☒ **A** $mol\ dm^{-3}$
- ☒ **B** $mol^2\ dm^{-6}$
- ☒ **C** $dm^3\ mol^{-1}$
- ☒ **D** atm^{-1}

Q6

(Total 1 mark)

7. For the equilibrium

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57.2\ kJ\ mol^{-1}$$

which one of the following changes would result in a different value of the equilibrium constant?

- ☒ **A** an increase in temperature
- ☒ **B** a decrease in pressure
- ☒ **C** an increase in pressure
- ☒ **D** an increase in the concentration of $NO_2(g)$

Q7

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

8. Solutions of concentration 0.1 mol dm^{-3} of iron(II) ions and silver(I) ions were mixed at room temperature and allowed to reach equilibrium.

$$Fe^{2+}(aq) + Ag^{+}(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$$

Which one of the following statements is true?

☒ **A** as the equilibrium position was approached, the forward reaction became slower until it stopped.

☒ **B** at the equilibrium position, no more Ag(s) reacted with $Fe^{3+}(aq)$.

☒ **C** at the equilibrium position, the rate of the forward reaction equalled the rate of the backward reaction.

☒ **D** no $Fe^{3+}(aq)$ reacted with Ag(s) until the equilibrium position was reached.

Q8

(Total 1 mark)

Leave blank

9. This question concerns four solutions, A to D. They were prepared by mixing equal volumes of 0.2 mol dm^{-3} solutions of two different substances. The substances were

A HCl(aq) and NaOH(aq)

B HCl(aq) and NaCl(aq)

C NH_3(aq) and NH_4Cl(aq)

D CH_3COOH(aq) and CH_3CO_2Na(aq)

Select, from A to D, the mixture which would:

(a) have the lowest concentration of hydrogen ions

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) act as a buffer of pH about 5

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(c) have a chloride ion concentration of 0.2 mol dm^{-3}.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q9**

(Total 3 marks)

Leave blank

10. This question concerns the titration of a solution of sodium hydroxide with a solution of hydrochloric acid. As the titration proceeds the pH of the mixture changes.

(a) What was the pH when 24.95 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq)?

☒ **A** 3

☒ **B** 6

☒ **C** 8

☒ **D** 11

(1)

(b) What was the pH when 25.05 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq)?

☒ **A** 3

☒ **B** 6

☒ **C** 8

☒ **D** 11

(1)

(c) Which one of the following indicators would be **most** suitable to use to determine the end point of this titration?

		pH range
☒ **A**	methyl violet	0–1.6
☒ **B**	universal indicator	3–11
☒ **C**	thymolphthalein	8.3–10.6
☒ **D**	alizarin yellow R	10.1–13.0

(1)

Q10

(Total 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

11. Which one of the following organic compounds does **not** exist?

☒ **A** an ester which is a structural isomer of a carboxylic acid $C_3H_6O_2$

☒ **B** a carboxylic acid which is a structural isomer of an ester $C_2H_4O_2$

☒ **C** an aldehyde which is a structural isomer of a ketone C_3H_6O

☒ **D** a ketone which is a structural isomer of an aldehyde C_2H_4O **Q11**

(Total 1 mark)

12. This question concerns a proposed two-stage synthetic route to prepare butanamide, $CH_3CH_2CH_2CONH_2$

$$\text{Carboxylic acid} \xrightarrow{} \text{Acyl chloride} \xrightarrow{NH_3} \text{butanamide}$$

(a) A suitable starting material for this preparation would have the formula

☒ **A** $CH_3CH_2CH_2COH$

☒ **B** $CH_3CH_2CH_2CH_2COOH$

☒ **C** $CH_3CH_2CH_2COOH$

☒ **D** $CH_3CH_2CH_2CH_2OOH$

(1)

(b) Each stage in the sequence produced a 50% yield of required product. What is the minimum number of moles of the carboxylic acid which should be used in order to produce one mole of butanamide?

☒ **A** 0.25

☒ **B** 2.00

☒ **C** 2.50

☒ **D** 4.00

(1)

(c) Which of the following reagents is needed to convert the carboxylic acid into the acyl chloride?

☒ **A** chlorine

☒ **B** phosphorus(V) chloride

☒ **C** hydrogen chloride

☒ **D** ethanoyl chloride

(1) **Q12**

(Total 3 marks)

Leave blank

13. This question concerns the following compounds containing four carbon atoms.

☒ **A** Butanoic acid, $CH_3CH_2CH_2COOH$

☒ **B** Butanone, $CH_3COCH_2CH_3$

☒ **C** Propyl methanoate, $HCOOCH_2CH_2CH_3$

☒ **D** Butanoyl chloride, $CH_3CH_2CH_2COCl$

Select, from A to D, the compound that

(a) can be made by the oxidation of a primary alcohol.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) would be expected to react most rapidly with ethanol.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(c) would have 4 different chemical shifts in its nmr spectrum and a broad absorption between 2500–3300 cm^{-1} in its infrared spectrum.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q13**

(Total 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

14. This question concerns the nucleophilic addition reaction between a carbonyl compound and hydrogen cyanide, HCN.

(a) Which one of the following carbonyl compounds would produce a racemic mixture?

☒ **A** CH_3COCH_3

☒ **B** C_2H_5CHO

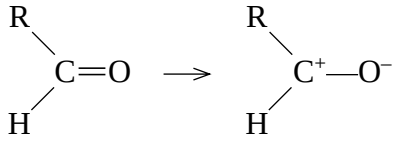
☒ **C** HCHO

☒ **D** $C_2H_5COC_2H_5$

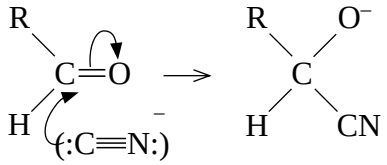
(1)

(b) Which of the following best represents the first step of the mechanism for this reaction with an aldehyde?

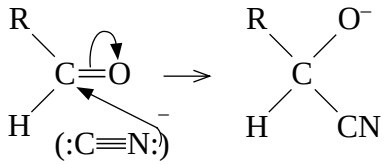
☒ **A**



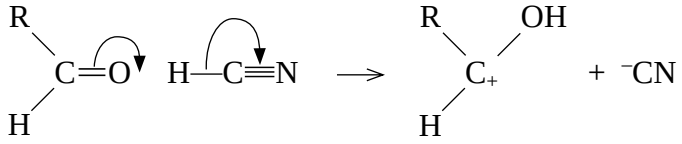
☒ **B**



☒ **C**



☒ **D**



(1) **Q14**

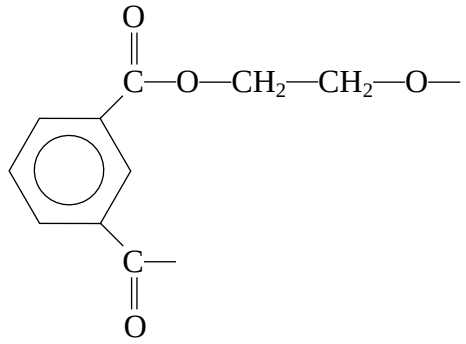
(Total 2 marks)

Leave blank

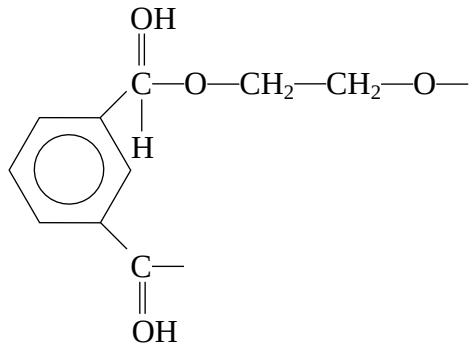
15. This question concerns the formation of a polymer.

(a) Which one of the following is a possible formula of the repeat unit of a polymer formed from ethane-1,2-diol and benzene-1,4-dicarboxylic acid.

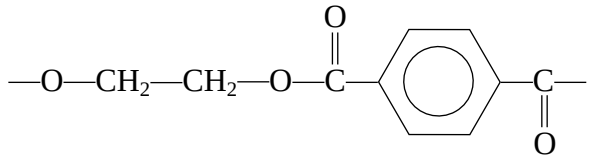
☒ **A**



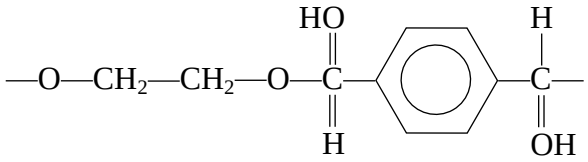
☒ **B**



☒ **C**



☒ **D**



(1)

(b) What type of reaction is this?

☒ **A** addition

☒ **B** condensation

☒ **C** dehydration

☒ **D** neutralisation

(1) **Q15**

(Total 2 marks)

TOTAL FOR SECTION A: 29 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

16. This question is about the pineapple flavouring used in sweets. It is an ester with the formula $C_3H_7COOCH_3$, which can be broken down into butanoic acid and methanol when mixed with hydrochloric acid.

The following equilibrium is set up:

$$C_3H_7COOCH_3(l) + H_2O(l) \rightleftharpoons C_3H_7COOH(l) + CH_3OH(l)$$

(a) Give the name of this ester.

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(1)

(b) Why does the ester have a comparatively low boiling point compared to the other three substances in the equation?

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(1)

(c) What is the name given to this type of reaction?

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(1)

Leave blank

*(d) Suggest the reasons why manufacturers choose to use the chemically manufactured pineapple flavouring rather than the natural product and why consumers might prefer to choose the natural product.

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(4)

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(e) In an experiment, 10.2 g (0.10 mol) of the ester was mixed with 18 cm^3 of 1.0 mol dm^{-3} hydrochloric acid and left until equilibrium had been reached. The hydrochloric acid acts as a catalyst and contains 18 g (1 mol) of water. At equilibrium, 4.4 g of butanoic acid was found to be present.

Molar mass of butanoic acid = 88 g; assume the total volume at equilibrium is 30 cm^3.

Give the expression for the equilibrium constant, K_c, for this equilibrium and calculate its value. Explain why it has no units.

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(5)

Q16

(Total 12 marks)

Leave blank

17. Methane reacts with steam in an endothermic reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(a) State the effect on the value of the equilibrium constant of an increase in temperature.

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(1)

*(b) Use your answer to (a) to explain the effect of this change on the position of equilibrium.

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(2)

Q17

(Total 3 marks)

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18. This question is about the reaction of magnesium with hydrochloric acid which takes place rapidly at room temperature.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g) \qquad \Delta H = -467 \text{ kJ mol}^{-1}$$

(a) Rewrite the equation omitting spectator ions.

(1)

(b) Suggest the sign of the following entropy changes for this reaction. Justify each of your answers.

(i) ΔS_{system}

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(2)

(ii) $\Delta S_{surroundings}$

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(2)

(iii) ΔS_{total}

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(1)

Leave blank

(c) A student carried out this experiment at five different temperatures in order to calculate the activation energy of the reaction. The student's laboratory record is shown below.

Method

Clean a strip of magnesium weighing 0.100 g with sand paper. Measure the temperature of 20 cm^3 of 1.00 mol dm^{-3} hydrochloric acid in a 100 cm^3 beaker. Add the magnesium ribbon, stir continuously, and time how long it takes for the magnesium to disappear. Repeat the experiment at four other temperatures.

Assumption: the initial rate of reaction is proportional to 1/time.

Results

Temperature /^0C	Temperature /K	1/T /K^{-1}	time /s	1/time /s^{-1}	ln 1/time
24	297	3.37×10^{-3}	45	0.0222	-3.81
33	306	3.27×10^{-3}	25	0.0400	-3.22
45	318	3.14×10^{-3}	11	0.0909	-2.40
56	329	3.04×10^{-3}	6	0.1667	-1.79
10	283	3.53×10^{-3}	122	0.0082	-4.80

The Arrhenius equation is $\ln k = -E_a/R \times (1/T) + \text{constant}$

ln 1/time is proportional to ln k and so a graph of ln 1/time will have the same gradient as that of the Arrhenius plot of ln k against 1/Temperature

The student plotted the graph of ln 1/time against 1/Temperature and from this the activation energy, E_A, was calculated as + 51.3 kJ mol^{-1}.

(i) Suggest the reason for cleaning the magnesium ribbon with sand paper.

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(1)

Leave blank

*(ii) Calculate the number of moles of hydrochloric acid used up when all the magnesium reacts in one experiment. Hence comment on whether the change in concentration during the reaction will have a significant effect on the validity of the assumption that the initial rate of reaction is proportional to 1/time. How would you overcome this potential error?

[Take the relative atomic mass of magnesium as 24 in this and subsequent calculations.]

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(5)

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(iii) Use the value of ΔH and other information given in the question to calculate the temperature change in an experiment assuming no energy is lost to the surroundings. Hence comment on whether this change in temperature will have a significant effect. How would you overcome this potential error?

[$\Delta H = -467$ kJ mol^{-1}.

heat produced = mass × specific heat capacity × change in temperature.

Assume that the specific heat capacity of the solution is 4.18 J K^{-1} g^{-1}]

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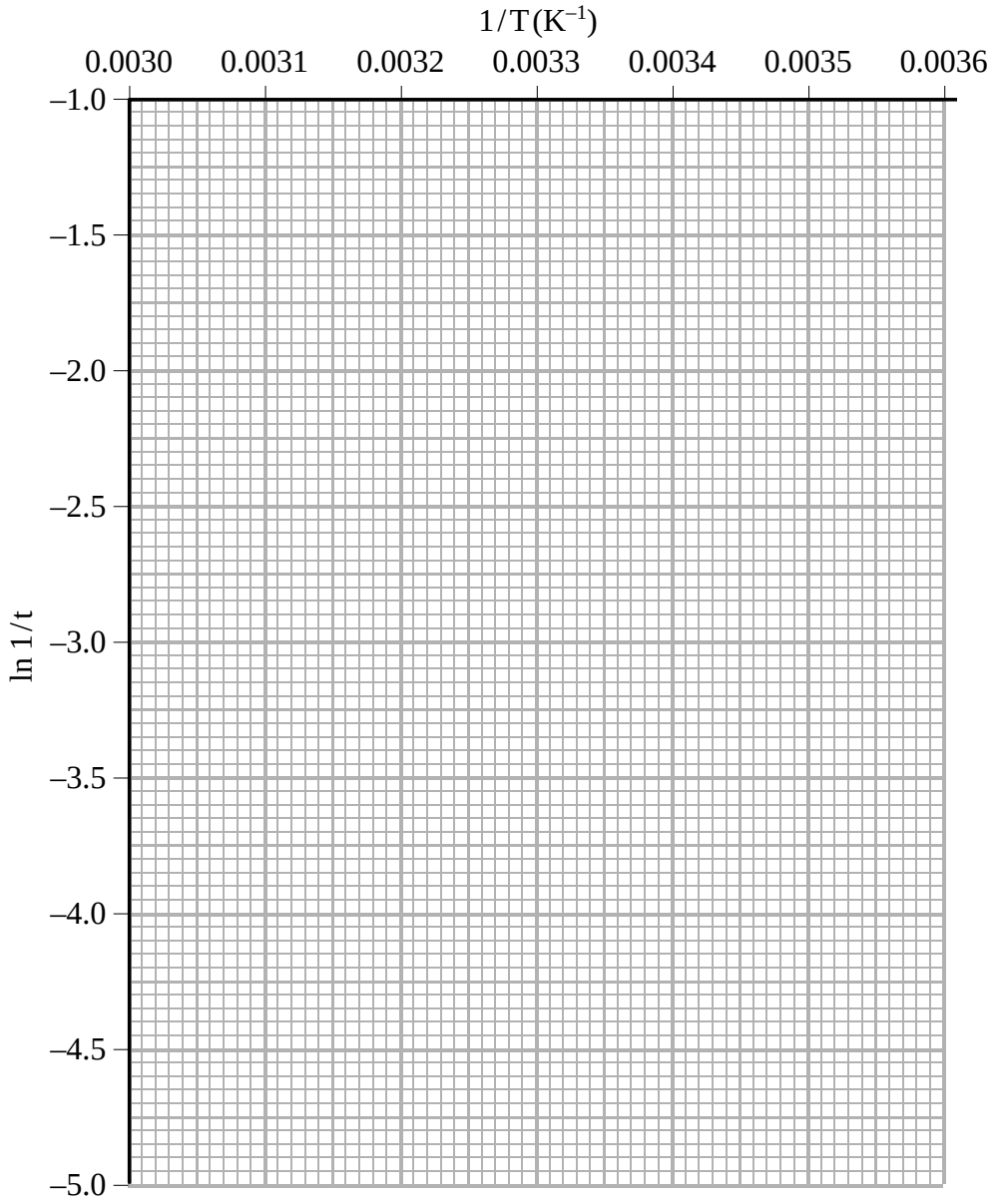
(4)

Leave blank

(iv) The most difficult thing to measure accurately is the time it takes for the magnesium to disappear and the time measured can be up to 2 seconds out. Assuming this error, calculate the shortest time at 56 °C **and** the longest time at 10 °C for this reaction.

Complete the table for these times. Plot the two points on the grid below and join them with a straight line. From the gradient, which equals $-E_A/R$, of this line calculate another value for the activation energy.

Temperature / °C	Temperature /K	1/T /K^{-1}	time /s	1/time /s^{-1}	ln 1/time
56	329	3.04×10^{-3}			
10	283	3.53×10^{-3}			



(4)

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(v) If the reaction mixture is not stirred, the magnesium tends to float on the surface of the acid.

Suggest how this would affect the measurements of the rate of the reaction.

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(1)

(vi) Suggest **two** other improvements the student could do to this experiment to improve the accuracy or validity of the results.

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(2)

(vii) If ethanoic acid of the same concentration and at the same temperature is used instead of hydrochloric acid, explain how the rate would differ.

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(1)

Q18

(Total 24 marks)

Leave blank

***19.** One step in the production of nitric acid is the oxidation of ammonia.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

This is carried out at 900 °C over a platinum-rhodium catalyst and is an example of heterogeneous catalysis.

Explain in terms of collision frequency and collision energy how the rate would change if the temperature were increased, and which of these causes the greater effect.

What is the difference between a heterogeneous and a homogeneous catalyst? Suggest **one** advantage of using a heterogeneous catalyst in processes such as this.

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Q19

(Total 6 marks)

TOTAL FOR SECTION B: 45 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

20. In moths a pheromone, **P**, acts as an attractant for the opposite sex. **P** has the molecular formula $C_7H_{12}O$.

What can be deduced about the structure of **P** from the following information?

(a) (i) 1 mole of **P** reacts with 1 mole of Br_2 molecules to form a compound with the formula $C_7H_{12}OBr_2$.

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(1)

(ii) When lithium tetrahydridoaluminate is reacted with **P** a compound with the formula $C_7H_{14}O$ is formed.

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(1)

(iii) **P** forms an orange precipitate with 2,4-dinitrophenylhydrazine.

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(1)

(iv) When **P** is heated with Fehling's or Benedict's solution, the solution remains blue.

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(1)

(v) **P** is a Z-isomer.

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(1)

Leave blank

(b) What does the following physical data tell you about the structure of **P**? Use your Data booklet where necessary.

*(i) The infrared spectrum of **P** has the following absorptions at wavenumbers above 1600 cm^{-1}.

3060 cm^{-1}

2920 cm^{-1}

1690 cm^{-1}

1660 cm^{-1}

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(3)

(ii) The nmr spectrum does **not** have a peak corresponding to a chemical shift, δ, of between 9 and 10.

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(1)

*(iii) The mass spectrum showed the presence of peaks at mass/charge ratios of 15 and 29, but no peak at 43.

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(3)

Leave blank

(c) Given that **P** has a straight chain of carbon atoms in its formula, use the information you have deduced above to suggest a displayed formula for the pheromone **P**.

(2)

(d) How could you use a purified sample of the orange precipitate in (a)(iii) to confirm the formula of **P**?

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(2)

Q20

(Total 16 marks)

TOTAL FOR SECTION C: 16 MARKS
TOTAL FOR PAPER: 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lathanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	C	H	0	5	/	1	Signature	

Paper Reference(s)

6CH05/1

Edexcel GCE

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Sample Assessment Material

Time: 1 hour 40 minutes

Examiner's use only		

Team Leader's use only		

Question Number	Leave Blank
Section A	
Section B	
Section C	
Total	

Materials required for examination
Data Booklet

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).
Do not use pencil. Use black or blue ink.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 24 questions in this question paper. The total mark for this paper is 90.
There are 28 pages in this question paper. Any blank pages are indicated.
Candidates may use a calculator.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 20(d), 21(c)(i), 21(c)(ii), 22(b)(i), 22(b)(ii), 23(a), 23(c)(iii), 24(a)(ii), 24(c), 24(d)(i) and 24(d)(ii). These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 25 minutes on this section. For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).

Each of the questions or incomplete statements in this section is followed by four suggested answers, A, B, C and D. Select the BEST answer in each case.

1. In a standard hydrogen electrode

☒ **A** the hydrogen gas is at one atmosphere pressure

☒ **B** a solution of 1 mol dm^{-3} sulfuric acid is used

☒ **C** a temperature of 273 K is maintained

☒ **D** a piece of shiny platinum foil is used **Q1**

(Total 1 mark)

2. For a redox reaction to be thermodynamically feasible, E_{cell} must be

☒ **A** positive

☒ **B** negative

☒ **C** greater than +0.3 V

☒ **D** more negative than –0.3 V **Q2**

(Total 1 mark)

Leave blank

3. The standard electrode potential for the electrode system based on the equation below is +1.51 V.

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$$

Which of the following statements about the electrode system is correct?

☒ **A** the electrode potential at pH 5 is +1.51 V.

☒ **B** $Mn^{2+}(aq)$ is acting as an oxidising agent.

☒ **C** changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential.

☒ **D** the electrode used in this half-cell is made of manganese.

Q3

(Total 1 mark)

4. Which of the following is always proportional to E_{cell} for a chemical reaction?

☒ **A** ΔH_r

☒ **B** ΔS_{system}

☒ **C** $\Delta S_{surroundings}$

☒ **D** ΔS_{total}

Q4

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

5. Methanol can be vigorously oxidised with an acidified solution containing dichromate(VI) ions, $Cr_2O_7^{2-}$, to form methanoic acid and chromic(III) ions.

(a) What are the oxidation numbers of **carbon** in methanol and methanoic acid?

		Methanol	Methanoic acid
☒	**A**	–1	+1
☒	**B**	–2	+2
☒	**C**	+1	–1
☒	**D**	+2	–2

(1)

(b) How many moles of methanol react with one mole of dichromate(VI) ion, $Cr_2O_7^{2-}$?

☒ **A** 1

☒ **B** ¾

☒ **C** 1½

☒ **D** 3

(1) **Q5**

(Total 2 marks)

6. Which of the following will **not** act as a ligand in the formation of complexes?

☒ **A** $C_6H_5NH_2$

☒ **B** CH_3NH_2

☒ **C** NH_4^+

☒ **D** NH_3 **Q6**

(Total 1 mark)

Leave blank

7. Which of the following ground state electron configurations corresponds to an element most likely to form an oxide with catalytic properties?

- ☒ **A** $1s^2\ 2s^2$
- ☒ **B** $1s^2\ 2s^2\ 2p^6\ 3s^2$
- ☒ **C** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
- ☒ **D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

Q7

(Total 1 mark)

8. **X**, **Y**, and **Z** are three different compounds from the list below. **X** and **Y** react together to form an ester. **X** and **Z** also react to give the same ester as **X** and **Y**, but less readily.

Compound **Y** could be

- ☒ **A** propanoyl chloride
- ☒ **B** propanoic acid
- ☒ **C** propan-1-ol
- ☒ **D** propanal

Q8

(Total 1 mark)

9. Which of the following isomers of $C_4H_{10}O$ has a chiral centre?

- ☒ **A** Butan-1-ol
- ☒ **B** Butan-2-ol
- ☒ **C** 2-methylpropan-1-ol
- ☒ **D** 2-methylpropan-2-ol

Q9

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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10. When the colourless liquid chlorobenzene is shaken with bromine water, the chlorobenzene becomes a yellow orange colour. What is the interpretation of this?

- ☒ **A** an addition compound of chlorobenzene and bromine has formed.
- ☒ **B** the chlorine atom has been replaced by a bromine atom.
- ☒ **C** a hydrogen atom has been replaced by a bromine atom.
- ☒ **D** the bromine is more soluble in chlorobenzene than in water.

Q10

(Total 1 mark)

11. What class of organic compound has a characteristic smell and gives a solution in water with a pH of about 10?

- ☒ **A** arene
- ☒ **B** amine
- ☒ **C** aldehyde
- ☒ **D** carboxylic acid

Q11

(Total 1 mark)

12. Which chemical term best describes what happens, when butylamine is added to a solution of a copper(II) salt?

- ☒ **A** precipitation
- ☒ **B** redox
- ☒ **C** proton transfer
- ☒ **D** complex formation

Q12

(Total 1 mark)

Leave blank

13. The substance of formula $(OCH_2CH_2OOCC_6H_4COOCH_2CH_2OOCC_6H_4CO)_n$ is a

- ☒ **A** polyester
- ☒ **B** natural oil or fat
- ☒ **C** detergent
- ☒ **D** protein

Q13

(Total 1 mark)

14. The optical isomers of alanine, $CH_3CH(COOH)NH_2$

- ☒ **A** have different melting points
- ☒ **B** rotate the plane of plane polarised light in opposite directions
- ☒ **C** react at different rates with ethanoyl chloride, CH_3COCl
- ☒ **D** both occur naturally in protein molecules

Q14

(Total 1 mark)

15. The rate equation for the reaction between aqueous sodium hydroxide and 2-chloro-2-methylpropane is

$$\text{Rate} = k[\text{2-chloro-2-methylpropane}]$$

The first step in the mechanism of this substitution reaction is

- ☒ **A** nucleophilic attack by OH^- ions on the carbon atom in the C–Cl bond
- ☒ **B** electrophilic attack by OH^- ions on the carbon atom in the C–Cl bond
- ☒ **C** the breaking of the C–Cl bond to form a carbocation
- ☒ **D** the simultaneous making of a O–C bond as the C–Cl bond breaks

Q15

(Total 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

16. When hydrogen cyanide, HCN, is added to ethanal, CH_3CHO, the resulting solution has no effect on the plane of polarisation of plane polarised light.

This is because

☒ **A** ethanal is not chiral

☒ **B** the product is not chiral

☒ **C** the intermediate is planar

☒ **D** the product is a racemic mixture

Q16

(Total 1 mark)

17. Two compounds may be similar in that they both have

A dative covalent bonds in their molecules

B at least one bond angle of 120° in each molecule

C non-polar molecules

D linear molecules

Select from **A**–**D**, the similarity between each of the compounds below.

(a) Benzene, C_6H_6 and cyclohexane, C_6H_{12}

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) Hydrogen cyanide, HCN, and carbon dioxide, CO_2

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q17**

(Total 2 marks)

Leave blank

18. This question is about the following organic compounds:

A Benzene, C_6H_6

B Glycine, NH_2CH_2COOH

C Propene, CH_3CHCH_2

D Propanone, CH_3COCH_3

Select, from **A–D**, the compound which would

(a) be a solid at room temperature

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(b) give a salt by reaction with sodium hydroxide

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

(c) give a sulfonic acid by reaction with fuming sulfuric acid

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1)

(d) form a precipitate when reacted with 2,4-dinitrophenylhydrazine

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(1) **Q18**

(Total 4 marks)

Leave blank

19. Select, from **A–D**, the type of interaction which best describes the bonding between

(a) adjacent polymer chains in $\text{+}[CH_2–CH_2]\text{+}_n$

☒ **A** dative covalent

☒ **B** London forces

☒ **C** ion-dipole

☒ **D** ionic

(1)

(b) copper ions and ammonia in $Cu(NH_3)_4^{2+}$

☒ **A** dative covalent

☒ **B** London forces

☒ **C** ion-dipole

☒ **D** ionic

(1) **Q19**

(Total 2 marks)

TOTAL FOR SECTION A: 25 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

Leave blank

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20. A firm claims that their iron tablets contain 10 mg of Fe^{2+} per tablet. A chemist wishes to check this by titration using potassium manganate(VII) and dilute sulfuric acid.

$$Fe^{2+}(aq) \rightleftharpoons Fe^{3+}(aq) + e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$$

(a) Why is the acid necessary?

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.....

(1)

(b) How many moles of Fe^{2+} react with one mole of MnO_4^-?

.....

(1)

Leave blank

(c) Each tablet contains 10 mg of Fe^{2+}.

(i) How many moles of Fe^{2+} are in one tablet?

(1)

(ii) Use your answer to (i) to calculate the volume of 0.010 mol dm^{-3} potassium manganate(VII) solution that would be needed to react with one tablet.

(2)

(iii) Is this a suitable volume to verify the integrity of the firm's claim? How would you alter the experiment to obtain a more suitable volume?

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(1)

Leave blank

*(d) The recommended consumption of Fe^{2+} per day is 14 mg. The tolerable upper level of consumption of Fe^{2+} per day is 45 mg.

The "10 mg iron tablets" produced by a pharmaceutical company contain between 9 and 11 mg of Fe^{2+}.

Discuss whether or not this range of iron content is acceptable.

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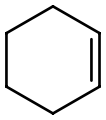
(2) **Q20**

(Total 8 marks)

Leave blank

21. (a) (i) Write the equation for the reaction between cyclohexene,  , and bromine.

(1)

(ii) Draw out the mechanism for this reaction.

(3)

(b) (i) Write the equation for the reaction between benzene,  , and bromine in the presence of a catalyst of anhydrous iron(III) bromide, $FeBr_3$.

.....

(1)

Leave blank

(ii) Draw out the mechanism for this reaction. Include an equation for the formation of the species that attacks the benzene ring.

(4)

(iii) Write an equation to show how the catalyst is regenerated.

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(1)

(c) Comment critically on:

*(i) the differences and similarities of the first steps involving the organic compounds in both reactions.

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(3)

Leave blank

*(ii) why the two intermediates formed in these first steps then react differently?

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(3)

(d) State the number of peaks in the proton nmr spectrum of the **product** of the reaction between cyclohexene and bromine.

.....

(1)

Q21

(Total 17 marks)

Leave blank

22. (a) (i) Give the electron configuration of:

Fe [Ar].....

Fe^{2+} [Ar].....

(1)

(ii) Draw the structure of the hexaaquairon(II) ion, $[Fe(H_2O)_6]^{2+}$, clearly showing its shape.

(1)

(iii) Give the equation for the complete reaction of hydroxide ions with a solution of hexaaquairon(II) ions.

(1)

(iv) State what you would **see** if the product mixture in (iii) is left to stand in air.

.....

.....

(1)

Leave blank

(b) Consider the equation for the half reaction

$$Fe^{2+} + 2e^- \rightleftharpoons Fe \qquad E^{\ominus} = -0.44\ V$$

*(i) Define the term **standard electrode potential** with reference to this electrode.

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(3)

*(ii) Explain why the value of $E^{\ominus}$ suggests that the iron will react with an aqueous solution of an acid to give Fe^{2+} ions and hydrogen gas.

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(2)

(iii) State why $E^{\ominus}$ values cannot predict that a reaction will occur, only that it is possible.

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(1)

Q22

(Total 10 marks)

Leave blank

23. Many modern day fabric softeners are manufactured with the liquid enclosed in a water soluble capsule. The capsule is based on a polymer of ethenol.

*(a) Explain why poly(ethenol) is soluble in water.

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.....

(2)

(b) Poly(ethenol) is made by hydrolysing poly(vinyl acetate), PVA, $[C_4H_6O_2]_n$.

(i) Draw the repeat unit of poly(ethenol)

.....

(1)

(ii) Write the formula of the monomer which polymerises to form poly(vinyl acetate), PVA (poly(ethenylethanoate)).

.....

(1)

(c) (i) 1,2-dibromocyclohexane reacts with ammonia to produce compound **A**, $C_6H_{14}N_2$. Give the structural formula of **A**.

(1)

Leave blank

(ii) Compound **A** reacts with hexanedioyl dichloride to produce a polymer.

Draw the structure of the repeating unit of this polymer.

(2)

***(iii)** Suggest why this polymer cannot be made into **strong** fibres.

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(2)

(d) Classify the **two** polymerisation reactions.

Poly(ethene) .....

Fibre .....

(1)

Q23

(Total 10 marks)

TOTAL FOR SECTION B: 45 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24. Read the passage below carefully and answer the questions which follow.

Stained glass and gemstones

Many medieval churches contain some very fine examples of stained glass coloured with transition metal compounds. Blue and green colours result from adding cobalt or copper oxides to molten glass. Copper oxide is added to colour the glass red, but it must be mixed with a strong reducing agent to give this colour. The red colour is so strong that it can appear black, and may need to be coated as a thin layer on top of colourless glass.

Like glass, many gemstones are based on silica and some on alumina. They are also coloured by transition metal compounds. A solid matrix of either silica, SiO_2, or alumina, Al_2O_3, has some of the silicon or aluminium replaced by a small quantity of a transition metal. Replacing about 5% of the aluminium ions in alumina with chromium(III) gives ruby, important in laser production. Replacement of aluminium ions by a mixture of iron(III) and titanium(III) gives sapphire. The metal coming in must have the same charge and about the same radius as the aluminium.

Based on 'Colour, A Chemical Overview' Chemistry Review volume 5, number 5, May 1996 written by Ken Kite

Leave blank

(a) The metals imparting colour to glass and gemstones mentioned in the passage are all transition elements.

(i) Define what is meant by a **transition element**.

.....

.....

(1)

*(ii) Explain the processes which lead to hydrated transition metal ions being coloured.

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(3)

(b) (i) Give the formulae of the copper oxide which causes the red colour in glass.

.....

(1)

(ii) The production of red copper oxide is involved in a test for a functional group in organic chemistry. Name the reagent used in this test and the functional group it detects.

Reagent .....

Functional group .....

(2)

Leave blank

*(c) Why would the addition of iron(II) oxide, FeO, or osmium(III) oxide, Os_2O_3, **not** replace aluminium ions in alumina?

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(2)

*(d) (i) Starting with a chromium(III) compound, state how it could be converted into a chromium(VI) compound, a chromium(II) compound and a complex ion.

You should include equations and colour changes in your answer.

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(7)

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*(ii) Discuss the chemistry of the use of chromium salts in breathalysers. Explain why they are no longer used and describe the chemistry of one modern type of breathalyser.

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(4) **Q24**

(Total 20 marks)

TOTAL MARKS FOR SECTION C: 20 MARKS
TOTAL MARKS FOR PAPER: 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	(18)
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lathanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

C Sample mark schemes

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Unit 1: The Core Principles of Chemistry

Section A

Question Number	Question	
1	Going across a period in the Periodic Table from left to right, the GENERAL trend is that A the bonding in the element itself changes from ionic to covalent B the number of neutrons in the nucleus increases C the first ionisation energy decreases D the metallic character increases	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
2	The electron configurations of argon, iron, chlorine and one other element are given below, but not in order. Which one represents the unnamed element? A $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$ B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
3	Buckminsterfullerene is a carbon molecule with formula C_{60} which can trap metal ions in its structure. Which of the following compounds of buckminsterfullerene would give a line of mass/ charge ratio at 837.3 in a mass spectrometer? A Na_4C_{60} B $K_3\ C_{60}$ C $Ca_3\ C_{60}$ D $Ag\ C_{60}$	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
4 (a)	Which equation is NOT balanced?	
	Correct Answer	Mark
	A	**1**

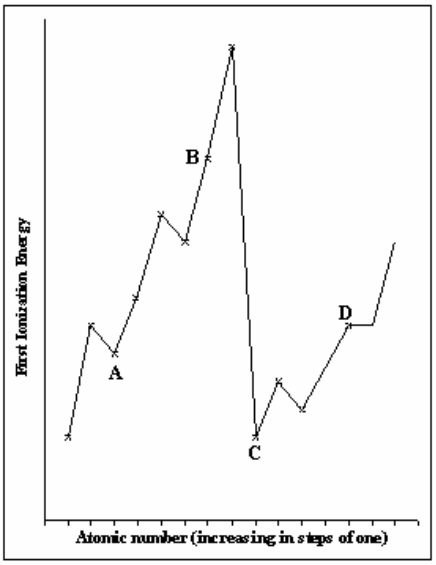
Question Number	Question	
4 (b)	Which equation shows incomplete combustion?	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
5	Which of the equations shown below represents the reaction for which ΔH is the standard enthalpy change of formation, $\Delta H_f^{\ominus}{}_{298}$, for ethanol, C_2H_5OH. Ethanol melts at 156 K and boils at 352 K. A $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(g)$ B $2C(s) + 3H_2(g) + O2(g) \rightarrow C2H_5OH(l)$ C $2C(s) + 3H_2(g) + O(g) \rightarrow C_2H_5OH(g)$ D $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
6 (a)	Which fuel, A, B, C or D, produces most energy per gram on complete combustion?	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
6 (b)	Scientists give governments advice on technical issues. What information would scientists use when advising governments on the choice of one of these fuels, if the aim was to minimise carbon dioxide production? A mass of carbon per gram of fuel B mass of carbon per kilojoules produced C number of kilojoules produced per gram D number of kilojoules produced per mole	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
7	Which of the following equations represents the first ionisation of sulfur? A $S(s) + e^- \rightarrow S^-(g)$ B $S(g) + e^- \rightarrow S^-(g)$ C $S(s) \rightarrow S^+(g) + e^-$ D $S(g) \rightarrow S^+(g) + e^-$	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
8	Which element marked on this graph is a halogen?  	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
9 (a)	The first ionisation energies of five consecutive members of the same group in the Periodic Table, in order of increasing atomic number.	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
9 (b)	The first five ionisation energies of an s-block element.	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
9 (c)	The first five ionisation energies of a noble gas.	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
10 (a)	Which hydrocarbon has the same empirical formula as its molecular formula?	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
10 (b)	Which has a molecular ion in the mass spectrum at mass/charge ratio = 58?	
	Correct Answer	Mark
	D	**1**

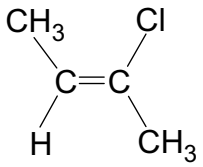
Question Number	Question	
10 (c)	Which is neither an alkane nor an alkene?	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
10 (d)	Which could be 2-methylpropane?	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
11(a)	Which compound could be made from one of the others in an addition reaction?	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
11 (b)	Which compound has E-Z isomers?	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
12	Chemists investigating the mechanism of the reaction of ethene and bromine thought that the first step was the addition of Br^+. To test this, they reacted bromine with ethene in the presence of sodium chloride. If their theory about the first step of the reaction was correct, which product might form as well as 1,2-dibromoethane? A CH_2BrCH_2Na B CH_2BrCH_2Cl C CH_2ClCH_2Cl D CH_2NaCH_2Na	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
13	Which of the following is the correct name for the compound below?  A Z-3-chlorobut-2-ene B E-3-chlorobut-2-ene C E-2-chlorobut-2-ene D Z-2-chlorobut-2-ene	
	Correct Answer	Mark
	C	**1**

Section B

Question Number	Question		
14 (a)	Write the equation for the reaction, including state symbols.		
	Acceptable Answers	Reject	Mark
	$CuCO_3(s) + H_2SO_4(aq) \rightarrow CO_2(g) + CuSO_4(aq) + H_2O(l)$		**1**

Question Number	Question	
14 (b)	The experiment was carried out using 0.025 moles of sulfuric acid of concentration 2.0 mol dm^{-3}. What volume of this sulfuric acid was used? A 5.0 cm^3 B 12.5 cm^3 C 50.0 cm^3 D 125.0 cm^3	
	Correct Answer	Mark
	B	**1**

Question Number	Question		
14 (c) (i)	It is usual to react the sulfuric acid with a slight excess of copper(II) carbonate. Calculate the mass of copper(II) carbonate needed if a 10% excess is required. [Molar mass of copper(II) carbonate = 123.5 g mol^{-1}]		
	Acceptable Answers	Reject	Mark
	(0.025 x 123.5) x 1.1 =(1) 3.396/ 3.40 / 3.4g (g) (1) OR 0.025 mol copper carbonate = 3.087/3.09 (g)(1) 3.087 +10% = 3.396/ 3.40/ 3.4 (g) Full marks for correct answer with no working		**2**

Question Number	Question		
14 (c) (ii)	A student doing this experiment chose to use a balance reading to 0.01 g in an attempt to work accurately. Was this choice of balance necessary from the point of view of accuracy? Explain your answer.		
	Acceptable Answers	Reject	Mark
	No, as copper carbonate is in excess	No, as molar mass is only to one decimal place	**1**

Question Number	Question		
14 (d)	The sulfuric acid is heated to boiling and the copper(II) carbonate is added in small portions. State the next step needed to prepare pure copper(II) sulfate solution? Justify your answer.		
	Acceptable Answers	Reject	Mark
	Filter to remove excess copper carbonate		**1**

Question Number	Question	
14 (e) (i)	What is the molar mass of $CuSO_4.5H_2O$?	
	Answer	Mark
	249.6	**1**

Question Number	Question		
14 (e) (ii)	3.98 g of $CuSO_4.5H_2O$ crystals were obtained in the experiment Calculate the percentage yield in this experiment.		
	Acceptable Answers	Reject	Mark
	Expected yield = 0.025 x 249.6 (1) = 6.24g % yield = (100 x 3.98/6.24)= 63.8/63.78% (1)		**2**

Question Number	Question		
15 (a) QWC (i) & (iii)	Describe the bonding in the element magnesium and explain why it is a good conductor of electricity.		
	Acceptable Answers	Reject	Mark
	(Lattice of) positively charged ions/ ions with 2+charge (1) held together by (electrostatic) attraction to delocalised electrons (1) Delocalised electrons /free electrons/ electrons in sea of electrons are free to move and carry charge / current (1)	Incorrect use of the terms atom or molecule for ion. Incorrect descriptions of delocalised electrons.	**3**

Question Number	Question		
15 (b) (i)	Draw a diagram (using dots or crosses) for the ions in magnesium fluoride showing ALL the electrons and the ionic charges on: the magnesium ion		
	Acceptable Answers	Reject	Mark
	Mg^{2+} shown as 2,8 (1)		**1**

Question Number	Question		
15 (b) (ii)	the fluoride ion		
	Acceptable Answers	Reject	Mark
	F^- shown as 2,8 (1)		**1**

Question Number	Question		
15 (c)	Under what conditions does magnesium fluoride conduct electricity? Explain your answer.		
	Acceptable Answers	Reject	Mark
	When molten/ when dissolved in water so that ions can move/ lattice breaks down (1)	Dissolved in other solvents. Reference to atoms or molecules rather than ions.	**1**

Question Number	Question		
15 (d) (i)	Use the data above to estimate the percentage isotopic composition of the sample of magnesium. Hence calculate the average atomic mass of this sample of magnesium.		
	Acceptable Answers	Reject	Mark
	77% ^{24}Mg, 10% ^{25}Mg, 13% ^{26}Mg (1) Average atomic mass $\frac{((77 \times 24)+(10 \times 25)+(13 \times 26))}{100} = 24.36 = 24.4g$ (1)		**2**

Question Number	Question		
15 (d) (ii)	Why do the three isotopes have the same chemical properties?		
	Acceptable Answers	Reject	Mark
	Have same electron configuration	Same number of electrons in outer orbit	**1**

Question Number	Question		
15 (e) (i)	Oceanographers studying plankton found that a sample of seawater contained 1.20 nanomol dm^{-3} of chlorophyll, $C_{55}H_{77}MgN_4O_5$. What mass of magnesium would be present in 1.00 cm^3 of this sample of seawater? Give your answer to THREE significant figures.		
	Acceptable Answers	Reject	Mark
	1.20 x 10^{-9} mol of Mg per dm^3 (1) (1.20 x 10^{-9} x 24.3 x 10^{-3}) = 2.92 x 10^{-11} / 29.2 x 10^{-12} (g) (1) max 1 for more/less than 3 significant figures eg 2.916		**2**

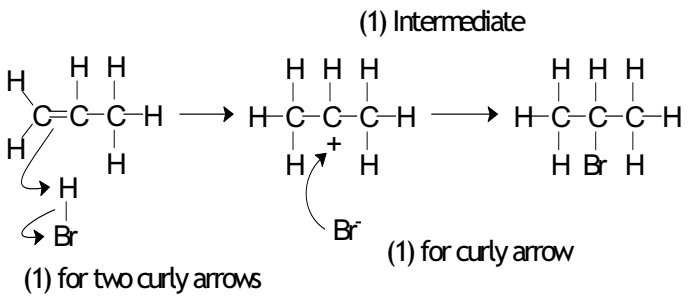
Question Number	Question	
15 (e) (ii)	X-ray diffraction can be used to locate atoms or ions in molecules like chlorophyll. X-rays are scattered by the electrons in atoms and ions. In chlorophyll the atoms of one of the elements still cannot be located with certainty by this technique. Suggest which element is most difficult to locate.	
	Correct Answer	Mark
	Hydrogen because it has the least number of electrons per atom	**1**

Question Number	Question		
16 (a)	Calculate the number of molecules in 50 dm^3 of nitrogen gas under these conditions. The Avogadro constant = 6.02×10^{23} mol^{-1}.		
	Acceptable Answers	Reject	Mark
	$(6.02 \times 10^{23} \times \frac{50}{24}) =$ 1.25×10^{24} / 1.254×10^{24} / 1.26×10^{24} Allow TE from a		**1** **1**

Question Number	Question		
16 (b)	Calculate the mass of sodium azide that would produce 50 dm^3 of nitrogen gas.		
	Acceptable Answers	Reject	Mark
	$M_r = (23 + 42) = 65$(1) Mass = $(2 \times 65 \times \frac{50}{72})$ (1) = 90/ 90.3g (1) Allow TE from (c)	Wrong unit eg kg	**3**

Question Number	Question	
16 (c)	What will happen to the temperature in the airbag when the reaction occurs?	
	Correct Answer	Mark
	decrease	**1**

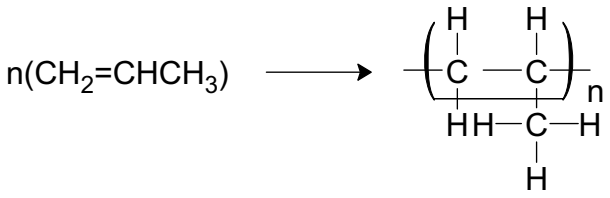
Question Number	Question		
16 (d) QWC (i) & (iii)	The airbag must be strong enough not to burst in an accident. An airbag which has burst in an accident is hazardous if the sodium azide in it has decomposed. Explain why this is so.		
	Acceptable Answers	Reject	Mark
	Sodium is hazardous (1) May go on fire with water/ produces flammable gas with water/ produces explosive gas with water/ produces strong alkali with water/ reacts with moisture on skin and becomes hot /corrosive (1) 2nd mark depends on reference to sodium	Unspecific comments about sodium being poisonous / toxic / flammable without reference to water.	**2**

Question Number	Question		
17 (a) (i)	Give the mechanism for REACTION 1.		
	Acceptable Answers	Reject	Mark
		Inaccurate placing of curly arrows	**3**

Question No	Question		
17 (a) (ii)	Explain why compound A and NOT its structural isomer is the major product in REACTION 1.		
	Acceptable Answers	Reject	Mark
	The secondary carbocation/carbonium ion is more stable than the primary (so forms when H^+ adds) OR The secondary carbocation/carbonium ion is stable because the methyl groups are electron donating		**1**

Question Number	Question		
17 (a) (iii)	Name compound A formed in REACTION 1.		
	Acceptable Answers	Reject	Mark
	2-bromopropane		**1**

Question Number	Question		
17 (b)	What is added in reaction 2 to make the product $CH_2(OH)CH(OH)CH_3$?		
	Acceptable Answers	Reject	Mark
	Acidified potassium manganate(VII) / potassium permanganate / $KMnO_4$((aq))		**1**

Question Number	Question		
17 (c)	Complete the balanced equation for the formation of poly(propene) in Reaction 3 USING DISPLAYED FORMULAE .		
	Acceptable Answers	Reject	Mark
	 balanced and double bond broken (1) CH_3 on side chain (1)	CH_3 in unbranched chain	**2**

Question Number	Question		
17 (d)	Poly(propene) fibres can be used to make fleece which is used by several horse racing courses to prevent the ground becoming frozen. State ONE advantage of using poly(propene) instead of natural fibres of similar cost.		
	Acceptable Answers	Reject	Mark
	Poly(propene) is non-biodegradable / won't break down in wet conditions (1)		**1**

Question Number	Question	
17 (e) (i)	One stage in the mechanism of REACTION 5 is shown below. $CH_3CH_2CH_3 + Cl^{\bullet} \rightarrow CH_3CH_2CH_2^{\bullet} + HCl$ What is this step?	
	Correct Answer	Mark
	propagation	**1**

Question Number	Question		
17 (e) (ii)	Give the name OR formula of the trace product present in the final mixture which gives evidence for this mechanism.		
	Acceptable Answers	Reject	Mark
	C_6H_{14} / hexane / Structural, displayed or skeletal formulae of hexane		**1**

Question Number	Question	
18 (a) (i)	Calculate the energy change which took place. The specific heat capacity of the solution is 4.20 J $g^{-1}K^{-1}$. Which is the correct value for the energy change in joules?	
	Correct Answer	Mark
	4410	**1**

Question Number	Question	
18 (a) (ii)	How many moles of copper(II) nitrate were used in the experiment?	
	Correct Answer	Mark
	0.015	**1**

Question Number	Question		
18 (a) (iii)	Calculate the enthalpy change for the reaction. You should include a sign and units in your answer.		
	Acceptable Answers	Reject	Mark
	(-4.41/ 0.015) = - 294 kJ mol^{-1} Value (1) Negative sign and units (1) TE for answer to (i)/ answer to (ii)		**2**

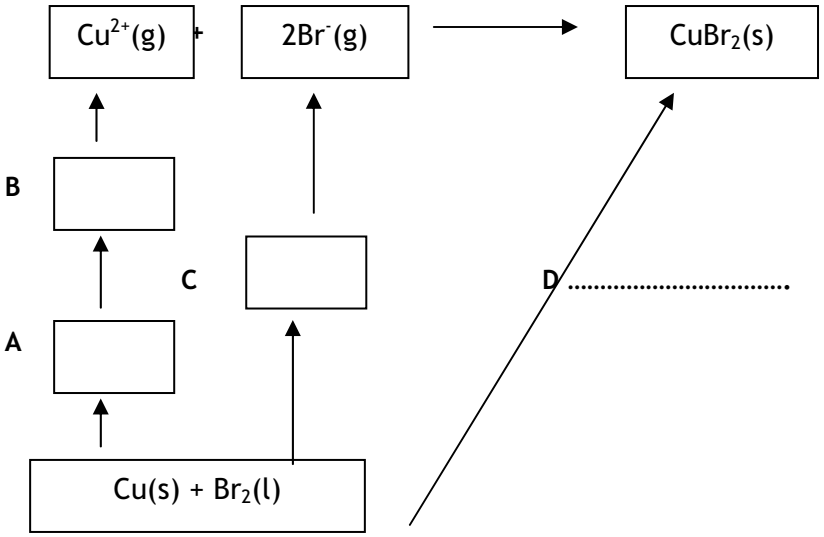
Question Number	Question		
18 (a) (iv) QWC (iii)	Suggest TWO changes you would make to the EQUIPMENT used in order to improve the accuracy of the result.		
	Acceptable Answers	Reject	Mark
	Any two of: Use an insulated container/(expanded) polystyrene cup Use a lid Use a thermometer calibrated to at least 0.5 °C		**2**

Question Number	Question		
18 (b) (i) QWC (i) & (iii)	the student used 2 g rather than 1 g of magnesium.		
	Acceptable Answers	Reject	Mark
	No effect, as all copper nitrate reacts anyway. (1) Enthalpy change is based on mass of solution heating up / SHC of the metal is very low. (1)		**2**

Question Number	Question	
18 (b) (ii) QWC (i) & (iii)	The heat losses that occurred from the student's beaker.	
	Correct Answer	Mark
	Yes, temperature rise is smaller than it should be(1) So enthalpy change less negative (1)	**2**

Question Number	Question		
18 (c)	The temperature in the self-heating can needs to increase by 60 °C to produce a hot drink. Suggest a change you could make to the mixture in the experiment in (a) to produce a greater temperature rise. You are NOT expected to do a calculation.		
	Acceptable Answers	Reject	Mark
	Use more concentrated solution (with correspondingly more magnesium).		**1**

Question Number	Question
19 (a)	On the following outline of a Born-Haber cycle complete the boxes A, B, and C by putting in the formula and state symbol for the appropriate species and writing the name of the enthalpy change at D.



	Acceptable Answers	Reject	Mark
	A Cu(g) B Cu^+ (g) C 2Br(g) 2 marks for all correct but max 1 if state symbols wrong/ missing 1 mark for 2 correct D $\Delta H_f^{(\ominus)}$ / (standard) enthalpy (change) of formation (of $CuBr_2$) (1)		**3**

Question Number	Question
19 (b)	Use the data to calculate a value for the lattice energy of copper(II) bromide. Give a sign and units in your answer.

	Acceptable Answers	Reject	Mark
	$\Delta H_f = \Delta H_{a(Cu)} + E_{m1(Cu)} + E_{m2(Cu)} + 2 \times \Delta H_{a(1/2\ Br2)} + 2 \times E_{aff(Br)} + \Delta H_{latt}$ OR Lattice energy = D-(other enthalpy changes) (1) Can be shown using the numbers = -141.8 - (338.3 + 746 + 1958 + 2x111.9 + 2x-342.6) = -141.8 - 2580.9 =-2722.7 =-2723 (kJ mol^{-1}) (2) max 1 if no multiples of 2 for Br max 2 (out of 3) if positive sign		**3**

Question Number	Question		
19 (c) (i)	What does this suggest about the nature of the bonding in copper(II) bromide?		
	Acceptable Answers	Reject	Mark
QWC	Not 100 % ionic/ has some covalent character	Answers where it is not clear that bonding has some intermediate character, but not entirely ionic or covalent	**1**

Question Number	Question		
19 (c) (ii)	Draw a diagram to show how the smaller copper ion alters the shape of the larger bromide ion.		
	Acceptable Answers	Reject	Mark
	Non-spherical bromide / negative ion with bulge towards copper / positive ion (1)		**1**

Unit 2: Application of Core Principles of Chemistry

Section A

Question Number	Question	
1	Which of the following best describes the molecular shape of carbon dioxide, CO_2? A Linear B Trigonal planar C Triangular D V-shaped	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
2	Which of the following species is polar? A NH_3 B BF_3 C SO_3 D CO_3^{2-}	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
3	Polar liquids are affected by electric fields. For which of the following liquids would a jet of the liquid be affected by an electric field? A hexane B cyclohexane C cyclohexene D cyclohexanol	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
4	What are the intermolecular forces in methanal, HCHO? A London forces only B hydrogen bonds and London forces C permanent dipole – permanent dipole only D permanent dipole – permanent dipole and London forces	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
5	Which of the following substances is likely to be insoluble in water? A methanol, CH_3OH B ethanol, CH_3CH_2OH C fluoromethane, CH_3F D hydrogen fluoride, HF	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
6	The following liquids have a similar number of electrons per molecule. Suggest which is likely to have the highest boiling point? A $CH_3CH_2CH_2CH_2CH_3$ B $(CH_3)_3COH$ C $CH_3CH_2CH(OH)CH_3$ D $CH_3CH_2CH_2CH_2OH$	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
7	Which concentrated acid should be used to dissolve a carbonate of a Group 2 metal to carry out a flame test? A ethanoic acid B hydrochloric acid C nitric acid D sulfuric acid	
	Answer	Mark
	B	**1**

Question Number	Question	
8	What colour does a barium salt give in a flame test? A colourless B green C red D yellow-red	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
9	Separate flame tests are carried out with lithium, sodium, potassium, magnesium, calcium and strontium salts. How many of these metal ions would colour the flame red? A 1 B 2 C 3 D 4	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
10	A Group 2 element reacts vigorously with water to produce a soluble hydroxide, which forms a white precipitate when neutralised by sulfuric acid and forms a carbonate which is very stable to heat. The element could be A magnesium B calcium C strontium D barium	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
11	The Group 2 metals, considered in order of increasing atomic number, show a decrease in A first ionisation energy B nuclear charge C chemical reactivity D ionic radius	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
12	When a Group 1 metal nitrate is heated, brown fumes are observed. The metal could be A lithium B sodium C rubidium D caesium	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
13	Methyl orange is red in acidic solutions and yellow in alkaline solutions. What is the colour of the indicator at the end point of a titration of aqueous sodium hydroxide solution with hydrochloric acid? A red B pink C orange D yellow	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
14	The volume, in cm^3, of 0.25 mol dm^{-3} hydrochloric acid required to neutralise 100 cm^3 of 0.125 mol dm^{-3} barium hydroxide solution, $Ba(OH)_2(aq)$, is A 25 B 50 C100 D 200	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
15	What is the oxidation number of SULFUR in sodium tetrathionate, $Na_2S_4O_6$? A -½ B +1½ C +2½ D + 5	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
16	Which of the following statements is FALSE? A iodine is more electronegative than bromine. B fluorine is more electronegative than chlorine. C metallic elements tend to react by loss of electrons. D chlorine is more electronegative than sulfur.	
	Correct Answer	Mark
	A	**1**

Question Number	Question
17	A commercial production of iodine involves the reduction of a solution of iodate(V) ions, IO_3^-, with a theoretical quantity of hydrogen sulfite ions, HSO_3^-. The equation for the reaction may be written $xIO_3^- + yHSO_3^- \longrightarrow zSO_4^{2-} + I_2 + 3H^+ + H_2O$ What are the balancing numbers x, y and z? A 5,2,2 B 2,5,2 C 2,5,5 D 5,5,2

	Correct Answer	Mark
	C	**1**

Question Number	Question
18	An organic compound is found to react with sodium metal and to react with acidified sodium dichromate(VI), but not to decolourise bromine water, nor to neutralise sodium carbonate solution. The liquid could be A ethanol B ethane C ethanoic acid D ethene

	Correct Answer	Mark
	A	**1**

Question Number	Question
19	Which of the following is not a greenhouse gas? A CH_4 B CO_2 C H_2O D N_2

	Correct Answer	Mark
	D	**1**

Question Number	Question
20	Which of the following fuels has the smallest carbon footprint? A petrol made from crude oil B hydrogen made from methane C ethanol made from sugar D coal

	Correct Answer	Mark
	C	**1**

Question Number	Question	
21	Which of the following would not lead to a greater sustainability in an industrial process? A using a catalyst that improves atom economy B running the reaction at a higher temperature C using biofuels to run the process D recycling waste products	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
22 (a)	The reason that 50% sulfuric acid was used rather than concentrated sulfuric acid is because concentrated sulfuric acid A would oxidise some of the bromide ions to bromine B would cause the reaction to go too fast. C would react with the bromide ions to produce hydrogen bromide. D is too hazardous a chemical.	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
22 (b)	The reaction mixture was distilled. The impure distillate did NOT contain A butan-1-ol B 1-bromobutane C sodium bromide D hydrogen bromide	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
22 (c)	The impure 1-bromobutane was washed with concentrated hydrochloric acid and shaken in a tap funnel with a base to remove acidic impurities. Which of the following would remove acidic impurities without reacting with the 1-bromobutane. A calcium hydroxide solution B sodium hydroxide solution C calcium chloride solution D sodium hydrogencarbonate solution	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
22 (d)	The 1-bromobutane was washed with water, dried and distilled. Which of the following is the correct procedure? A heat the liquid to 118 °C and collect the substance given off B heat the liquid to 100 °C and collect the substance given off C boil the liquid and collect the fraction that boils off between 116 and 120 °C D boil the liquid and collect the fraction that boils off between 98 and 102 °C	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
23	Which of the following changes in conditions would increase the equilibrium yield of ethanoic acid? A increase pressure B decrease pressure C increase temperature D add a catalyst	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
24 (a)	propanone from propanal and propan-1-ol A B C D	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
24 (b)	propanal from propanone and propan-1-ol A B C D	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
24 (c)	propan-1-ol from propanal and propanone A B C D	
	Correct Answer	Mark
	A	**1**

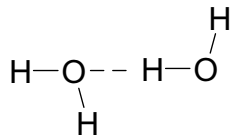
Section B

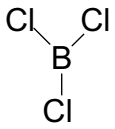
Question Number	Question		
25 (a)	Draw the structural formulae of the two isomers with molecular formula C_3H_8O which are alcohols. Give the names of these alcohols.		
	Acceptable Answers	Reject	Mark
	$CH_3CH_2CH_2OH$ (1) Propan-1-ol (1) $CH_3CH(OH)CH_3$ (1) Propan-2-ol (1)		**4**

Question Number	Question		
25 (b) (i)	Give the name and structural formula of the carboxylic acid formed when the primary alcohol C_3H_8O is fully oxidised.		
	Acceptable Answers	Reject	Mark
	Propanoic acid (1) $CH_3CH_2CO_2H$ (1)		**2**

Question Number	Question		
25 (b) (ii)	**State the reagents used for this oxidation.**		
	Acceptable Answers	Reject	Mark
	Either sodium dichromate ((VI)) or potassium manganate(VII) (1) Sulfuric acid (1) dependent on 1st mark Ignore concentrated/dilute		**2**

Question Number	Question		
26 (a) (i)	Name the type of bonding that exists between water molecules.		
	Acceptable Answers	Reject	Mark
	Hydrogen/H bonding (1)		**1**

Question Number	Question		
26 (a) (ii)	Draw a diagram to show this bonding. Use displayed formulae of two water molecules. Clearly mark and label the bond angle BETWEEN the water molecules.		
	Acceptable Answers	Reject	Mark
	 (1) Either Bond angle 180° around the hydrogen bonded H atom, i.e. O---H—O	O---H-O if not in a straight line	**2**

Question Number	Question		
26 (b) (i)	Draw the boron trichloride molecule, BCl_3, making its shape clear. Mark the bond angle on your diagram.		
	Acceptable Answers	Reject	Mark
	trigonal planar diagram (1)  *IGNORE name* 120 ° marked on diagram (1) – *stand alone*		**2**

Question Number	Question		
26 b (ii) QWC (i) & (iii)	Explain why boron trichloride has this shape.		
	Acceptable Answers	Reject	Mark
	There are 3 bond pairs (of electrons) around the B atom (1) And no lone pairs (1) They repel to a position of minimum repulsion/maximum separation (1)	maximum repulsion	**3**

Question Number	Question		
26 (b) (iii)	Explain why a B-Cl bond is polar.		
	Acceptable Answers	Reject	Mark
	B and Cl have different electronegativities / Cl more electronegative than B *OR different electronegativities explained*		**1**

Question Number	Question		
26 (b) (iv)	Explain why a BCl_3 molecule is non-polar.		
	Acceptable Answers	Reject	Mark
	Dipoles (or vectors) cancel/symmetrical molecule/ centres of positive and negative charges coincide (1) *IGNORE* polarity cancels	Charges cancel	1

Question Number	Question		
26 (b) (v)	Name the strongest intermolecular force between boron trichloride molecules.		
	Acceptable Answers	Reject	Mark
	London forces / instantaneous dipole-Induced dipole/dispersion /v der Waals *Temporary or instantaneous can be used instead of induced* (1)	"dipole" forces/ permanent dipole/ dipole-dipole vdw	**1**

Question Number	Question		
27 (a) (i)	Why was ethanol added to each test-tube?		
	Acceptable Answers	Reject	Mark
	Make halogenoalkanes miscible with silver nitrate/$AgNO_3$ solution OR to dissolve halogenoalkanes/acts as solvent (1)		**1**

Question Number	Question		
27 (a) (ii)	The mechanism of this reaction is similar to that of the reaction between halogenoalkanes and aqueous hydroxide ions. What feature of a water molecule enables it to act as a nucleophile in this reaction? Suggest the mechanism for the reaction between water and 1-iodobutane. (You may represent 1-iodobutane as RCH_2I).		
	Acceptable Answers	Reject	Mark
	Feature of water molecule: The oxygen atom has a lone pair of electrons (1) Either an S_N2 mechanism Arrow from O of water towards C atom (1) and arrow from C-I σ bond to I atom (1) transition state with no charge (1) Ignore final loss of H^+ and formation of I^- Or an S_N1 mechanism Arrow from C-I σ bond to I (1) intermediate with + charge and I^- ion (1) arrow from O of water to C+ of intermediate (1) Ignore final loss of H^+		**4**

Question Number	Question		
27 (a) (iii)	What is the colour of the precipitate in the third test-tube? A cream B white C yellow D grey		
	Correct Answer	Reject	Mark
	C		**1**

Question Number	Question		
27 (a) (iv)	Name the precipitate which forms slowly in the FIRST test-tube.		
	Acceptable Answers	Reject	Mark
	Silver((I)) chloride (1) Ignore capitals		**1**

Question Number	Question		
27 (a) (v)	Ammonia solution is added to the precipitate in the FIRST test-tube. Describe what you would observe.		
	Acceptable Answers	Reject	Mark
	Precipitate dissolves/disappears/clears (1)	Precipitate changes colour	**1**

Question Number	Question		
27 (a) (vi) QWC (i-iii)	Suggest, why the rates of hydrolysis of the three halogenoalkanes are different, in terms of bonding and kinetics.		
	Acceptable Answers	Reject	Mark
	Must be given in a logical sequence C-I bond is weakest (and break more easily) (1) Because the iodine atom is the largest / greatest bond length (1) So lowest activation energy (1) Or reverse argument: e.g. C-Cl bond strongest	Cl is more electronegative than I OR Cl forms a carbocation more readily than C-I	**3**

Question Number	Question		
27 (b) QWC (i) & (iii)	One method of the manufacture of alcohols is to react steam with an alkene. For example. $C_2H_4(g) + H_2O(g) \longrightarrow C_2H_5OH(l)$ Suggest TWO reasons why this method is preferred to the hydrolysis of halogenoalkanes.		
	Acceptable Answers	Reject	Mark
	Any two from three: 100 % atom economy (1) higher cost of halogenoalkanes/halogenoalkanes are made from alcohols (1) alkenes readily available from oil (1)		**2**

Question Number	Question		
27 (c) (i)	State the hazard when the heating is stopped.		
	Acceptable Answers	Reject	Mark
	suck back (1)		**1**

Question Number	Question		
27 (c) (ii)	How would you minimise the risk associated with this hazard?		
	Acceptable Answers	Reject	Mark
	remove delivery tube from water/add Bunsen valve (1)		**1**

Section C

Question Number	Question		
28 (a) (i)	The record of measurements reveals faults both in procedure and the recording of measurements. State ONE fault in each of these.		
	Acceptable Answers	Reject	Mark
	Procedure: Only one titration carried out/ no check on accuracy of titration OR 1000 cm^3 volume to large to fit in titration flask (1) Recording: Did not record burette readings to 0.05 cm^3 / 1 decimal place / sufficient precision / recording only one significant figure in a titration reading (1)		**2**

Question Number	Question		
28 (a) (ii)	Calculate the number of moles of sodium thiosulfate used in the titration.		
	Acceptable Answers	Reject	Mark
	4.65×10^{-5} / 4.7×10^{-5} / 0.0000465 / 0.000047 (mol)		**1**

Question Number	Question		
28 (a) (iii)	Use your answer to (ii) to calculate the number of moles of iodine reacted.		
	Acceptable Answers	Reject	Mark
	2.3×10^{-5} / 0.000023 OR candidates answer to (ii) divided by 2		**1**

Question Number	Question		
28 (a) (iv)	Deduce the concentration of chlorine, in mol dm^{-3}, in the swimming pool water.		
	Acceptable Answers	Reject	Mark
	2.3×10^{-5} / 0.000023 mol dm^{-3} OR candidates answer to (iii)		**1**

Question Number	Question		
28 (b) (i) QWC (i) & (iii)	State and explain the type of reaction that occurs when chlorine attacks a metal, using the example of iron.		
	Acceptable Answers	Reject	Mark
	Redox as chlorine removes/gains electrons from the metal (and is reduced) (1) And metal gives/loses electrons to the chlorine (and is oxidised) (1) Redox is essential in order to score both marks The gain / loss of electrons can be awarded from two ionic half equations.		**2**

Question Number	Question		
28 (b) (ii)	Suggest ONE other reason why the use of chlorine is undesirable in swimming pools.		
	Acceptable Answers	Reject	Mark
	Chlorine is (highly) toxic/poisonous/irritant OR chlorine has an unpleasant smell (1)		**1**

Question Number	Question		
28 (b) (iii)	Give the formula for calcium chlorate(I).		
	Acceptable Answers	Reject	Mark
	$Ca(ClO)_2$ (1)		**1**

Question Number	Question		
28 (b) (iv) QWC (ii)	Chlorine dioxide, ClO_2, undergoes a disproportionation reaction when it reacts with water. $4ClO_2 + 2H_2O \rightarrow HClO + 3HClO_3$ Explain, in terms of oxidation numbers, why this is a disproportionation reaction.		
	Acceptable Answers	Reject	Mark
	Cl is oxidised from +4 (in ClO_2) to +5 (in $HClO_3$) (1) and is reduced (from +4) to +1 (in HClO) (1)		**2**

Question Number	Question		
28 (c) QWC (i-iii)	Discuss and explain the science community's advice that CFCs should no longer be used in aerosols, foams and refrigerants. Support your answer with one or more equations.		
	Acceptable Answers	Reject	Mark
QWC	Any of the five points below as long as they are logically connected and use correct scientific terminology plus 1 mark for an equation to a maximum of 6 marks. • CFCs are greenhouse gases • because their dipole moment changes when they vibrate • and so contribute to global warming • depletion of the ozone layer • causes less ozone to absorb UV radiation (from the sun) /increase in UV reaching the earth's surface • causes skin cancer / mutations • CFCs (decompose photolytically to) produce free radical chlorine atoms/ Cl radicals • Recognition that one Cl radical can cause the destruction of many thousands of ozone molecules / or mention of chain reaction Equations $Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$ $ClO^{\bullet} + O^{\bullet} \rightarrow Cl^{\bullet} + O_2$ Either equation or other relevant equation (1)		**6**

Unit 4: General Principles of Chemistry I

Section A

Question Number	Question	
1 (a)	The hydrolysis of 1-bromobutane using hydroxide ions $C_4H_9Br(l) + OH^-(aq) \rightarrow C_4H_9OH(l) + Br^-(aq)$	
	Correct Answer	Mark
	D Titration with standard acid solution	**1**

Question Number	Question	
1 (b)	The decomposition of the benzenediazonium ion $C_6H_5N_2^+(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + H^+(aq)$	
	Correct Answer	Mark
	A Collecting and measuring the volume of gas	**1**

Question Number	Question	
1 (c)	The reaction of acidified potassium manganate(VII) with propan-2-ol to give propanone and manganese(II) sulphate	
	Correct Answer	Mark
	B Colorimetry	**1**

Question Number	Question	
1 (d)	the catalytic decomposition of hydrogen peroxide	
	Correct Answer	Mark
	A Collecting and measuring the volume of gas	**1**

Question Number	Question	
2	1,2-dibromoethane reacts with potassium iodide dissolved in methanol according to the equation: $C_2H_4Br_2 + 2KI \rightarrow C_2H_4 + 2KBr + I_2$ The rate equation for this reaction is A rate = $k[KI]^2[C_2H_4Br_2]$ B rate = $k[KI]^2$ C rate = $k[C_2H_4Br_2]$ D not possible to deduce from this information	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
3	For the reaction between sodium bromate(V) and sodium bromide in acidic solution, the rate equation is: Rate = $k[BrO_3^-][Br^-][H^+]^2$ When the concentrations of all three reactants are doubled, the rate will increase by a factor of A 4 B 6 C 8 D 16	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
4 (a)	Calculate ΔS_{system}, in J mol^{-1} K^{-1}, for this reaction. A - 175.8 B + 175.8 C - 64.2 D + 64.2	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
4 (b)	Calculate $\Delta S_{surroundings}$, in J mol^{-1} K^{-1}, for this reaction at 298 K. A - 192 B + 192 C - 0.192 D + 0.192	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
5	For the equilibrium, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ Which is the correct expression for K_p? A $\dfrac{[NH_3(g)]^2}{[N_2(g)][H_2(g)]^3}$ B $\dfrac{P_{N_2(g)} P_{H_2(g)}}{P_{NH_3(g)}}$ C $\dfrac{P^2_{NH_3(g)}}{P_{N_2(g)} P^3_{H_2(g)}}$ D $\dfrac{P_{N_2(g)} P^3_{H_2(g)}}{P^2_{NH_3(g)}}$	
	Correct Answer	Mark
	C $\dfrac{P^2_{NH_3(g)}}{P_{N_2(g)} P^3_{H_2(g)}}$	**1**

Question Number	Question	
6	The expression for K_c for the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is $K_c = \frac{[SO_3(g)]^2}{[SO_2(g)]^2[O_2(g)]}$ What are the units of K_c in this equilibrium expression? A mol dm^{-3} B mol^2 dm^{-6} C dm^3 mol^{-1} D atm^{-1}	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
7	For the equilibrium $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -57.2$ kJ mol^{-1} which one of the following changes would result in a different value of the equilibrium constant? A an increase in temperature B a decrease in pressure C an increase in pressure D an increase in the concentration of $NO_2(g)$	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
8	Solutions of concentration 0.1 mol dm^{-3} of iron(II) ions and silver(I) ions were mixed at room temperature and allowed to reach equilibrium. $Fe^{2+}(aq) + Ag^+(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$ Which one of the following statements is true? A As the equilibrium position was approached, the forward reaction became slower until it stopped. B At the equilibrium position, no more Ag(s) reacted with Fe3+(aq). C At the equilibrium position, the rate of the forward reaction equalled the rate of the backward reaction. D No $Fe^{3+}(aq)$ reacted with Ag(s) until the equilibrium position was reached.	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
9 (a)	Have the lowest concentration of hydrogen ions	
	Correct Answer	Mark
	C $NH_3(aq)$ and $NH_4CL(aq)$	**1**

Question Number	Question	
9 (b)	Act as a buffer of pH about 5	
	Correct Answer	Mark
	D $CH_3COOH(aq)$ and $CH_3CO_2Na(aq)$	**1**

Question Number	Question	
9 (c)	Have a chloride ion concentration of 0.2 mol dm^{-3}	
	Correct Answer	Mark
	B HCl(aq) and NaCl(aq)	**1**

Question Number	Question	
10 (a)	What was the pH when 24.95 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq). A 3 B 6 C 8 D 11	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
10 (b)	What was the pH when 25.05 cm^3 of 1.00 mol dm^{-3} NaOH(aq) had been added to 25 cm^3 of 1.00 mol dm^{-3} HCl(aq). A 3 B 6 C 8 D 11	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
10 (c)	Which one of the following indicators would be MOST suitable to use to determine the end point of this titration? pH range A methyl violet 0-1.6 B universal Indicator 3-11 C thymolphthalein 8.3-10.6 D alizarin yellow R 10.1-13.0	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
11	Which one of the following organic compounds does NOT exist? A an ester which is a structural isomer of a carboxylic acid $C_3H_6O_2$ B a carboxylic acid which is a structural isomer of an ester $C_2H_4O_2$ C an aldehyde which is a structural isomer of a ketone C_3H_6O D a ketone which is a structural isomer of an aldehyde C_2H_4O	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
12 (a)	A suitable starting material for this preparation would have the formula A $CH_3CH_2CH_2COH$ B $CH_3CH_2CH_2CH_2COOH$ C $CH_3CH_2CH_2COOH$ D $CH_3CH_2CH_2CH_2OOH$	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
12 (b)	Each stage in the sequence produced a 50% yield of required product. What is the minimum number of moles of the carboxylic acid which should be used in order to produce one mole of butanamide? A 0.25 B 2.00 C 2.50 D 4.00	
	Correct Answer	Mark
	D	**1**

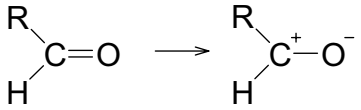
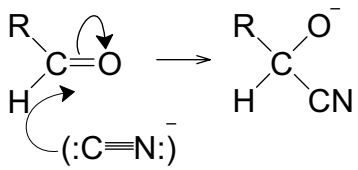
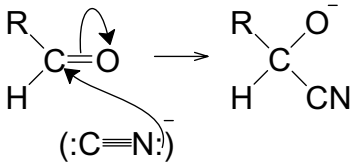
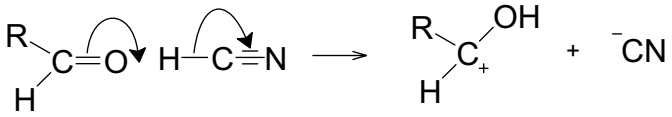
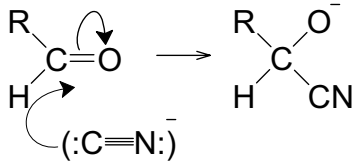
Question Number	Question	
12 (c)	Which of the following reagents is needed to convert the carboxylic acid into the acyl chloride? A chlorine B phosphorus(V) chloride C hydrogen chloride D ethanoyl chloride	
	Correct Answer	Mark
	B	**1**

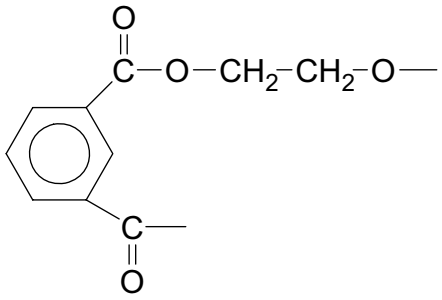
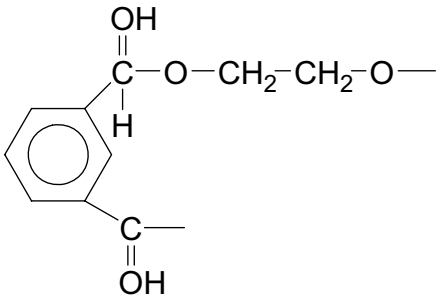
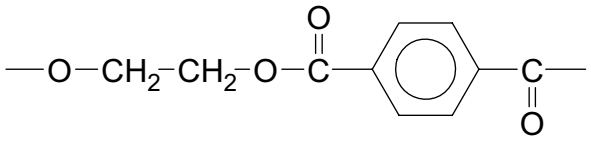
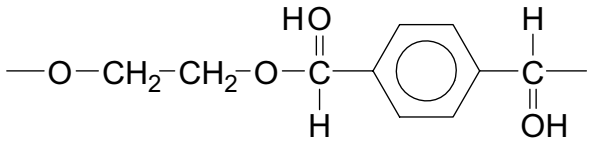
Question Number	Question	
13 (a)	Can be made by the oxidation of a primary alcohol.	
	Correct Answer	Mark
	A Butanoic acid, $CH_3CH_2CH_2COOH$	**1**

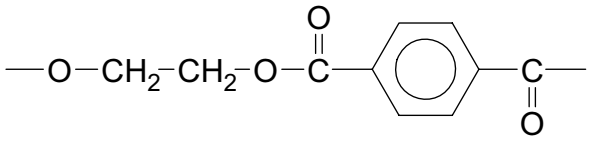
Question Number	Question	
13 (b)	Would be expected to react most rapidly with ethanol.	
	Correct Answer	Mark
	D Butanoyl chloride, $CH_3CH_2CH_2COCl$	**1**

Question Number	Question	
13 (c)	Would have 4 different chemical shifts in its nmr spectrum and an absorption at 2500 – 3300 cm^{-1} in its infrared spectrum. Use the data booklet as a source of information.	
	Correct Answer	Mark
	A Butanoic acid, $CH_3CH_2CH_2COOH$	**1**

Question Number	Question	
14 (a)	Which one of the following carbonyl compounds would produce a racemic mixture? A CH_3COCH_3 B C_2H_5CHO C HCHO D $C_2H_5COC_2H_5$	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
14 (b)	Which of the following best represents the first step of the mechanism for this reaction with an aldehyde? **A**  **B**  **C**  **D** 	
	Correct Answer	Mark
	B 	**1**

Question Number	Question
15 (a)	Which one of the following is a possible formula of the repeat unit of a polymer formed from ethane-1,2-diol and benzene-1,4-dicarboxylic acid. **A**  **B**  **C**  D 

	Correct Answer	Mark
	C 	**1**

Question Number	Question
15 (b)	What type of reaction is this? A dddition B condensation C dehydration D neutralisation

	Correct Answer	Mark
	B	**1**

Section B

Question Number	Question		
16 (a)	Give the name of this ester.		
	Acceptable Answers	Reject	Mark
	methyl butanoate Accept Methyl butaneoate	'an' missing	**1**

Question Number	Question		
16 (b)	Why does the ester have a comparatively low boiling point compared to the other three substances in the equation?		
	Acceptable Answers	Reject	Mark
	the other three substances can form **intermolecular** hydrogen bonds with themselves but the ester cannot.	Discussion of London Forces	**1**

Question Number	Question	
16 (c)	What is the name given to this type of reaction?	
	Correct Answer	Mark
	Hydrolysis	**1**

Question Number	Question		
16. (d) QWC (i-iii)	Suggest the reasons why manufacturers choose to use the chemically manufactured pineapple flavouring rather than the natural product and why consumers might prefer to choose the natural product.		
	Acceptable Answers	Reject	Mark
	Must cover advantages and disadvantages. Must **not** be contradictory **Advantages to manufacturers: (any two)** • not dependent on weather, seasons etc • consistent taste /concentration/more consistent • quality • or alternative ideas **Disadvantages to consumers : (any two)** • some people put off by 'non-natural' food • may not taste the same as natural product which may • contain other impurities • unable to describe the product as organic or alternative ideas	Cost with no justification	**4**

Question Number	Question		
16 (e)	Give the expression for the equilibrium constant, K_c, for this equilibrium and calculate its value. Explain why it has no units.		
	Acceptable Answers	Reject	Mark
	$K_c = \frac{[C_3H_7COOH(l)][CH_3OH(l)]}{[C_3H_7COOCH_3(l)][H_2O(l)]}$ (1) Accept eq subscripts **Moles at equilibrium** / **Concentration / mol dm^{-3}** **butanoic acid** = 4.4/88 = 0.05 / 1.67 **methanol** 0.05 / 1.67 **ester (methyl butanoate)** 0.05 / 1.67 **water** 0.95 / 31.7 all four equilibrium moles = (1) Conc at equilibrium = equilibrium moles ÷ 0.030 (1) $K_c = \frac{1.67 \times 1.67}{1.67 \times 31.7}$ (1) = 0.053 (1) ignore significant figures unless value given to 1 s.f. The units cancel because both the top and bottom of the fraction have units of concentration squared. Or same number of moles on both sides of the equation (1)	Absence of square brackets	**5**

Question Number	Question		
17 (a)	State the effect on the value of the equilibrium constant of an increase in temperature.		
	Acceptable Answers	Reject	Mark
	Value of equilibrium constant increases (1)		**1**

Question Number	Question		
17. (b) QWC (i) & (iii)	Use your answer to (i) to explain the effect of this change on the position of equilibrium.		
	Acceptable Answers	Reject	Mark
	If the equilibrium constant increases then more products will be formed (1) And the position of equilibrium will move to the right (1)		**2**

Question Number	Question		
18 (a)	Rewrite the equation omitting spectator ions.		
	Acceptable Answers	Reject	Mark
	$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ Accept state symbols omitted		**1**

Question Number	Question		
18 (b) (i)	ΔS_{system}		
	Acceptable Answers	Reject	Mark
	Positive because a gas is given off (1) which is more disordered and so has more entropy (1)		**2**

Question Number	Question		
18 (b) (ii)	$\Delta S_{surroundings}$		
	Acceptable Answers	Reject	Mark
	Positive because the reaction is exothermic (1) and = - $\Delta H/T$ (1)		**2**

Question Number	Question		
18 (b) (iii)	ΔS_{total}		
	Acceptable Answers	Reject	Mark
	Positive because the reaction occurs / total entropy change is the sum of the two positive values above.		**1**

Question Number	Question		
18 (c) (i)	Suggest the reason for cleaning the magnesium ribbon with sand paper.		
	Acceptable Answers	Reject	Mark
	Surface coated with magnesium oxide (which would react to form water rather than hydrogen).		1

Question Number	Question		
18 (c) (ii) QWC (i-iii)	Calculate the number of moles of hydrochloric acid used up when all the magnesium reacts in one experiment and hence comment on whether the change in concentration during the reaction will have a significant effect on the validity of the assumption that the initial rate is proportional to 1/time. How would you overcome this potential error? [Take the relative atomic mass of magnesium as 24 in this and subsequent calculations]		
	Acceptable Answers	Reject	Mark
	Initial number of moles of HCl = 20 x 1 /1000 = 0.02 Number of moles of Mg = 0.1 / 24 = 0.00417 (1) number of moles of HCl which reacts is 0.00834 (1) Therefore number of moles of HCl left = 0.01166 (1) Ignore sig figs so the concentration nearly halves which would significantly reduce the rate and so make the assumption that the initial rate is proportional to 1/time invalid / inaccurate. (1) Increase the volume of acid to (at least) 50 cm^3 (1) Or measure the time to produce less than the full amount of gas Or use a smaller piece of magnesium. (1)		5

Question Number	Question		
18 (c) (iii)	Use the value of ΔH and other information given in the question to calculate the temperature change in an experiment assuming no energy is lost to the surroundings. Hence comment on whether this change in temperature will have a significant effect. How would you overcome this potential error? [ΔH = -467 kJ mol^{-1}. Assume that the specific heat capacity of the solution is 4.18 J K^{-1} g^{-1}]		
	Acceptable Answers	Reject	Mark
	Energy given out = 467 000 x 0.1/24 J = 1 946 J 20 x 4.18 x ΔT = 1 946 (1) $\Delta T = 23.3^{(o)}$ (1) Accept units of degrees celsius or kelvin This temperature change would significantly increase the rate of the reaction (1) Carry out the reaction in a water bath of constant temperature/use a larger volume of more dilute acid (1)		**4**

Question Number	Question		
18 (c) (iv)	The most difficult thing to measure accurately is the time it takes for the magnesium to disappear and the time measured can be up to 2 seconds out. Assuming this error, calculate the shortest time at 56 ^{0}C AND the longest time at 10 ^{0}C for this reaction. Complete the table for these times. Plot the two points on the grid below and join them with a straight line. From the gradient, which equals $-E_A/R$, of this line calculate another value for the activation energy.		
	Acceptable Answers	Reject	Mark
	At 329 time 4s 1/time = 0.25 s^{-1} ln(rate) = -1.39 (1) At 283 time 124s 1/time = 0.00806s^{-1} ln(rate) = -4.82 (1) [graph to be drawn] Plot line with new gradient = - 3.43 / 0.00049 = - 7 000 (1) Accept -6800 to -7200 Activation energy = + 7 000 x 8.31 = + 58.2 kJ mol^{-1} (1)		**4**

Question Number	Question		
18 (c) (v)	If the reaction mixture is not stirred, the magnesium tends to float on the surface of the acid. Suggest how this would affect the measurements of the rate of the reaction.		
	Acceptable Answers	Reject	Mark
QWC	Rate of reaction reduced because less surface area in contact with the acid. (1)		1

Question Number	Question		
18 (c) (vi)	Suggest TWO other improvements the student could do to this experiment to improve the accuracy or validity of the results.		
	Acceptable Answers	Reject	Mark
	Any two •Repeat the experiment at each of the temperatures •obtain an initial rate eg by measuring the volume of gas given off before the reaction is complete. •Other sensible suggestions.		2

Question Number	Question		
18 (c) (vii)	If ethanoic acid of the same concentration and at the same temperature is used instead of hydrochloric acid, explain how the rate would differ.		
	Acceptable Answers	Reject	Mark
	The rate should be lower, since ethanoic acid is a weaker acid (compared to hydrochloric acid) and so there will be a lower concentration of hydrogen ions present.		**1**

Question Number	Question		
19 **QWC** **(i-iii)**	One step in the production of nitric acid is the oxidation of ammonia. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ This is carried out at 900 °C over a platinum-rhodium catalyst and is an example of heterogeneous catalysis. Explain in terms of collision frequency and collision energy how the rate would change if the temperature were increased, and which of these causes the greater effect. What is the difference between a heterogeneous and a homogeneous catalyst? Suggest ONE advantage of using a heterogeneous catalyst in processes such as this.		
	Acceptable Answers	Reject	Mark
	Answer must be given in a logical order, addressing all the points using precise terminology • Collision **frequency** increases as particles moving more quickly (1) • More collisions have sufficient energy to overcome activation energy / more molecules on collision have energy ≥ activation energy (1) • A greater **proportion** of collisions result in reaction (1) • Collision energy has greater effect (1) • Homogeneous all in same phase and heterogeneous in different phases / gas and solid (1) • No need to separate products from catalyst (1)	More collisions More successful collisions	**6**

Question Number	Question		
20 (a) (i)	1 mole of P reacts with 1 mole of Br_2 molecules to form a compound with the formula $C_7H_{12}OBr_2$.		
	Acceptable Answers	Reject	Mark
	contains **one** carbon-carbon double bond Accept alkene		**1**

Question Number	Question		
20 (a) (ii)	When lithium tetrahydridoaluminate is reacted with P a compound with the formula $C_7H_{14}O$ is formed.		
	Acceptable Answers	Reject	Mark
	is a carbonyl compound / C=O group reduced (to CH(OH)) Accept aldehyde or ketone		**1**

Question Number	Question		
20 (a) (iii)	P forms an orange precipitate with 2,4-dinitrophenylhydrazine.		
	Acceptable Answers	Reject	Mark
	is a carbonyl compound Accept aldehyde or ketone		**1**

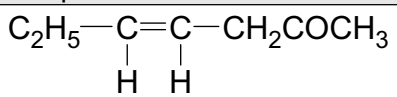
Question Number	Question		
20 (a) (iv)	When P is heated with Fehling's or Benedict's solution, the solution remains blue.		
	Acceptable Answers	Reject	Mark
	is a ketone / P is not an aldehyde	aldehyde	**1**

Question Number	Question		
20 (a) (v)	P is a Z-isomer.		
	Acceptable Answers	Reject	Mark
	has two groups on the same side of a C=C Accept cis isomer		**1**

Question Number	Question		
20 (b) (i) QWC (ii) & (iii)	The infrared spectrum of P has the following absorptions at wavenumbers above 1600 cm^{-1}. 3060 cm^{-1} 2920 cm^{-1} 1690 cm^{-1} 1660 cm^{-1}		
	Acceptable Answers	Reject	Mark
	3060 alkene (C-H stretching) 2920 alkane (C-H stretching) 1690 ketones (C=O stretching) 1660 alkene (C=C stretching) 4 Correct → 3 marks 3 Correct → 2 marks 2 Correct → 1 mark		**3**

Question Number	Question		
20 (b) (ii)	The nmr spectrum does NOT have a peak corresponding to a chemical shift, δ, of between 9 and 10.		
	Acceptable Answers	Reject	Mark
	not an aldehyde		**1**

Question Number	Question		
20 (b) (iii) QWC (ii) & (iii)	The mass spectrum showed the presence of peaks at mass/charge ratios of 15 and 29, but no peak at 43.		
	Acceptable Answers	Reject	Mark
	15 CH_3 group (1) 29 C_2H_5 group (1) 43 no C_3H_7 group (1)		**3**

Question Number	Question		
20 (c)	Given that P has a straight chain of carbon atoms in its formula, use the information you have deduced above to suggest a displayed formula for the pheromone P.		
	Acceptable Answers	Reject	Mark
	 ketone and Z (1) rest of molecule (1) Accept Fully displayed		**2**

Question Number	Question		
20 (d)	How could you use a purified sample of the orange precipitate in (a)(iii) to confirm the formula of P?		
	Acceptable Answers	Reject	Mark
	Measure its melting temperature (1) And compare with data book values (1)		**2**

Unit 5: General Principles of Chemistry II

Section A

Question Number	Question	
1	In a standard hydrogen electrode A the hydrogen gas is at one atmosphere pressure B a solution of 1 mol dm^{-3} sulfuric acid is used C A temperature of 273 K is maintained D a piece of shiny platinum foil is used	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
2	For a redox reaction to be thermodynamically feasible, E_{cell} must be A positive B negative C greater than + 0.3 V D more negative than - 0.3V	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
3	The standard electrode potential for the electrode system based on the equation below is +1.51 V. $MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ Which of the following statements about the electrode system is correct? A the electrode potential at pH 5 is +1.51 V. B $Mn^{2+}(aq)$ is acting as an oxidising agent. C changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential. D the electrode used in this half cell is made of manganese.	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
4	Which of the following is always proportional to E_{cell} for a chemical reaction? A ΔH_r B ΔS_{system} C $\Delta S_{surroundings}$ D ΔS_{total}	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
5 (a)	What are the oxidation numbers of carbon in methanol and methanoic acid? Methanol Methanoic acid A -1 +1 B -2 +2 C +1 -1 D +2 -2	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
5 (b)	How many moles of methanol react with one mole of dichromate (VI) ion $Cr_2O_7^{2-}$? A 1 B $^3/_4$ C $1^1/_2$ D 3	
	Correct Answer	Mark
	C 1½	**1**

Question Number	Question	
6	Which of the following will NOT act as a ligand in the formation of complexes? A $C_6H_5NH_2$ B CH_3NH_2 C NH_4^+ D NH_3	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
7	Which of the following ground state electron configurations corresponds to an element most likely to form an oxide with catalytic properties? A $1s^2\ 2s^2$ B $1s^2\ 2s^2\ 2p^6\ 3s^2$ C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
8	X, Y, and Z are three different compounds from the list below. X and Y react together to form an ester. X and Z also react to give the same ester as X and Y, but less readily. Compound Y could be A propanoyl chloride B propanoic acid C propan-1-ol D propanal	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
9	Which of the following isomers of $C_4H_{10}O$ has a chiral centre? A Butan-1-ol B Butan-2-ol C 2-methylpropan-1-ol D 2-methylpropan-2-ol	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
10	When the colourless liquid chlorobenzene is shaken with bromine water, the chlorobenzene becomes a yellow orange colour. What is the interpretation of this? A an addition compound of chlorobenzene and bromine has formed. B the chlorine atom has been replaced by a bromine atom. C a hydrogen atom has been replaced by a bromine atom. D the bromine is more soluble in chlorobenzene than in water.	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
11	What class of organic compound has a characteristic smell and gives a solution in water with a pH of about 10? A Arene B Amine C Aldehyde D Carboxylic acid	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
12	Which chemical term best describes what happens when butylamine is added to a solution of a cobalt(II) salt? A precipitation B redox C proton transfer D complex formation	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
13	The substance of formula $(OCH_2CH_2OOCC_6H_4COOCH_2CH_2OOCC_6H_4CO)_n$ is a A polyester B natural oil or fat C detergent D protein	
	Correct Answer	Mark
	A	**1**

Question Number	Question	
14	The optical isomers of alanine, $CH_3CH(COOH)NH_2$ A have different melting points B rotate the plane of plane polarised light in opposite directions C react at different rates with ethanoyl chloride, CH_3COCl D both occur naturally in protein molecules	
	Correct Answer	Mark
	B	**1**

Question Number	Question	
15	The rate equation for the reaction between aqueous sodium hydroxide and 2-chloro-2-methylpropane is Rate = k[2-chloro-2-methylpropane] The first step in the mechanism of this substitution reaction is A nucleophilic attack by OH^- ions on the carbon atom in the C-Cl bond B electrophilic attack by OH^- ions on the carbon atom in the C-Cl bond C the breaking of the C-Cl bond to form a carbocation D the simultaneous making of a O-C bond as the C-Cl bond breaks	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
16	When hydrogen cyanide, HCN, is added to ethanal, CH_3CHO, the resulting solution has no effect on the plane of polarisation of plane polarised light. This is because A ethanal is not chiral B the product is not chiral C the intermediate is planar D the product is a racemic mixture	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
17 (a)	Benzene, C_6H_6 and cyclohexane, C_6H_{12} A B C D	
	Correct Answer	Mark
	C	**1**

Question Number	Question	
17 (b)	Hydrogen cyanide, HCN, and carbon dioxide, CO_2 A B C D	
	Correct Answer	Mark
	D	**1**

Question Number	Question	
18 (a)	be a solid at room temperature A B C D	
	Correct Answer	Mark
	B Glycine, NH_2CH_2COOH	**1**

Question Number	Question	
18 (b)	give a salt by reaction with sodium hydroxide A B C D	
	Correct Answer	Mark
	B Glycine, NH_2CH_2COOH	**1**

Question Number	Question	
18 (c)	give a sulfonic acid by reaction with fuming sulfuric acid A B C D	
	Correct Answer	Mark
	A Benzene, C_6H_6	**1**

Question Number	Question	
18 (d)	form a precipitate when reacted with 2,4-dinitrophenylhydrazine A B C D	
	Correct Answer	Mark
	D Propanone, CH_3COCH_3	**1**

Question Number	Question	
19 (a)	adjacent polymer chains in $(-CH_2- CH_2-)_n$ A Dative covalent B London forces C Ion-dipole D Ionic	
	Correct Answer	Mark
	B London forces	**1**

Question Number	Question	
19 (b)	copper ions and ammonia in $Cu(NH_3)_4^{2+}$ A dative covalent B London forces C ion-dipole D ionic	
	Correct Answer	Mark
	A Dative covalent	**1**

Section B

Question Number	Question	
20 (a)	Why is the acid necessary ?	
	Correct Answer	Mark
	MnO_4^- needs acid to be reduced to Mn^{2+}	**1**

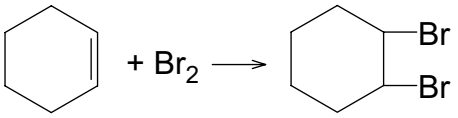
Question Number	Question	
20 (b)	How many moles of Fe^{2+} react with one mole of MnO_4^- ?	
	Correct Answer	Mark
	5	**1**

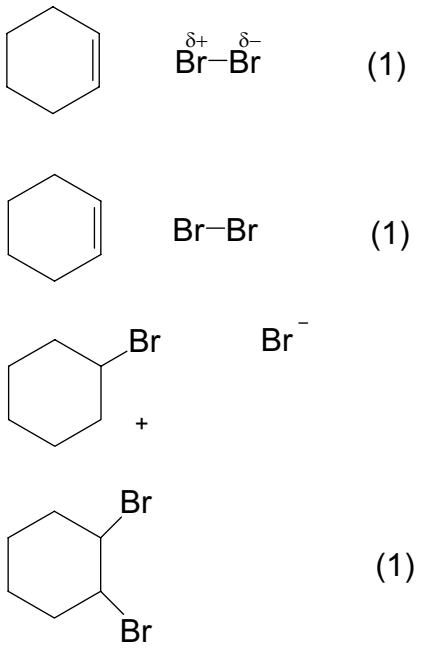
Question Number	Question		
20 (c)(i)	How many moles of Fe2+ are in one tablet is:		
	Acceptable Answers	Reject	Mark
	1.79×10^{-4}		1

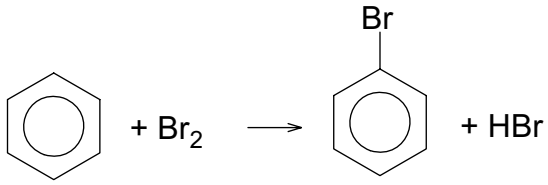
Question Number	Question		
20 (c)(ii)	Use your answer to (i) to calculate the volume of 0.010 mol dm-3 potassium manganate(VII) solution that would be needed to react with one tablet.		
	Acceptable Answers	Reject	Mark
	$1.79x10^{-4}$ mols of Fe^{2+} in one tablet $\therefore$ mols of MnO_4^- = $\frac{1}{5} x 1.79x10^{-4}$ (1) 0.01 mol in 1000 cm^3 $\therefore \frac{1}{5} x 1.79x10^{-4}$ in $\frac{1000}{0.01} x \frac{1.79x10^{-4}}{5}$ = 3.58 = 3.6 cm^3 (1)		1

Question Number	Question		
20 (c)(iii)	Is this a suitable volume to verify the integrity of the firm's claim? How would you alter the experiment to obtain a more suitable volume?		
	Acceptable Answers	Reject	Mark
	No, titration value too low Either: use more tablets Or: use more dilute solution of $KMnO_4$		**1**

Question Number	Question		
20 (d) QWC (i) & (iii)	The recommended consumption of Fe^{3+} per day is 14 mg. The tolerable upper level of consumption of Fe^{2+} per day is 45 mg. The "10 mg iron tablets" produced by a pharmaceutical company contain between 9 and 11 mg of Fe^{2+}. Discuss whether or not this range of iron content is acceptable.		
	Acceptable answers	Reject	Mark
	(It is acceptable because) well below the maximum safe limit (1) Not significantly different from recommended daily dose OR Variation in body mass means that different doses are acceptable OR only if max 1 tablet per day is written on the bottle (1)		**2**

Question Number	Question	
21 (a) (i)	Write the equation for the reaction between cyclohexene,  , and bromine.	
	Correct Answer	Mark
		**1**

Question Number	Question	
21 (a) (ii)	Draw out the mechanism for this reaction.	
	Correct Answer	Mark
		**3**

Question Number	Question		
21 (b) (i)	Write the equation for the reaction between benzene,  , and bromine in the presence of a catalyst of anhydrous iron(III), FeBr3.		
	Acceptable Answers	Reject	Mark
			**1**

Question Number	Question		
21 (b) (ii)	Draw out the mechanism for this reaction. Include an equation for the formation of the species that attacks the benzene ring.		
	Acceptable Answers	Reject	Mark
	$Br_2 + FeBr_3 \rightarrow Br^+ + FeBr_4^-$ / δ+ δ- Br—$FeBr_4$ (1) Step 1 Arrow from ring towards Br^+ (1) Intermediate (1) Step 2 Arrow from bond, ring to H, to inside ring (and from $FeBr_4^-$ to H^+) and formation of products (1)		**4**

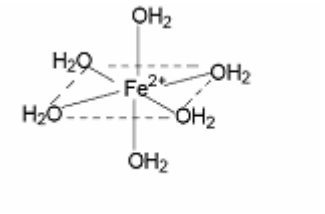
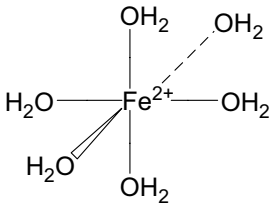
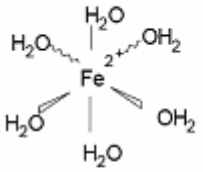
Question Number	Question		
21 (b) (iii)	Write an equation to show how the catalyst is regenerated		
	Acceptable Answers	Reject	Mark
	$FeBr_4^- + H^+ \rightarrow FeBr_3 + HBr$		**1**

Question Number	Question		
21 (c) (i) QWC (i) & (iii)	Comment critically on the differences and similarities of the first steps involving the organic compounds in both reactions.		
	Acceptable Answers	Reject	Mark
	Both attacked by an electrophile (1) Due to stability of delocalised ring (1) benzene attacked by (stronger electrophilic) Br^+ rather than $Br^{\delta+}$ in Br_2 (1)		**3**

Question Number	Question		
21 (c) (ii) QWC (i) & (iii)	Comment critically on why the two intermediates formed in these first steps then react differently?		
	Acceptable Answers	Reject	Mark
	<u>Cyclohexene</u> Addition of Br^- does not involve bond breaking /results in more exothermic reaction than loss of H^+ (1) <u>Benzene</u> No Br^- available in benzene reaction (1) Stability of ring regained by loss of H^+ (1)		**3**

Question Number	Question		
21 (d)	State the number of peaks in the proton nmr spectrum of the product of the reaction between cyclohexene and bromine.		
	Acceptable Answers	Reject	Mark
	Three / 3		**1**

Question Number	Question		
22 (a) (i)	Give the electron configuration of: Fe [Ar] Fe^{2+} [Ar]		
	Acceptable Answers	Reject	Mark
	Fe[Ar] $3d^6 4s^2$ in either order, allowing superscripts to be subscripts Fe[Ar] $3d^6$ or $3d^6 4s^0$ in either order, allowing superscripts to be subscripts Letter d must be lower case	Any other letters	**1**

Question Number	Question		
22 (a) (ii)	Draw the structure of the hexaaquairon(II) ion, $[Fe(H_2O)_6]^{2+}$ clearly showing its shape.		
	Acceptable Answers	Reject	Mark
	 OR  *OR*  *Instead of dotted line* *ALLOW bond to H of H_2O (except on left side if OH_2 is given)* *IGNORE charge unless incorrect*		**1**

Question Number	Question		
22 (a) (iii)	Give the equation for the complete reaction of sodium hydroxide ions with a solution of hexaaquairon(II) ions.		
	Acceptable Answers	Reject	Mark
	$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow [Fe(OH)_2(H_2O)_4] + 2H_2O$ OR $[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$		**1**

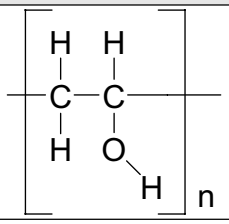
Question Number	Question		
22 (a) (iv)	State what you would SEE if the product mixture in (iii) is left to stand in air.		
	Acceptable Answers	Reject	Mark
	Green precipitate/solid → Foxy-red/red-brown/brown/orange Both colours **and** precipitate/solid needed	Just "Darkens"	**1**

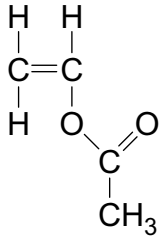
Question Number	Question		
22 (b) (i) QWC (i) & (iii)	Define the term STANDARD ELECTRODE POTENTIAL with reference to this electrode.		
	Acceptable Answers	Reject	Mark
	Emf of cell/ potential difference of cell containing Fe (1) dipping into a 1 mol dm^{-3} Fe^{2+} solution (1) And standard hydrogen electrode/half cell OR hydrogen electrode and 1 mol dm^{-3} H^+ and 1 atm H_2 OR description of standard hydrogen electrode (1) IGNORE temperature	 'SHE'	**3**

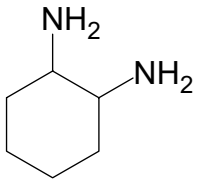
Question Number	Question		
22 (b) (ii) QWC (i) & (iii)	Explain why the value of $E^{\ominus}$ suggests that the iron will react with an aqueous solution of an acid to give Fe^{2+} ions and hydrogen gas.		
	Acceptable Answers	Reject	Mark
	Emf of hydrogen electrode is zero – *stated or implied* e.g. if calclulate E_{cell} = +0.44 V (1) Potential for the reaction is positive so reaction is feasible OR Fe half cell has more negative electrode potential OR H^+ and $(\frac{1}{2})H_2$ has a more positive electrode potential (1)		**2**

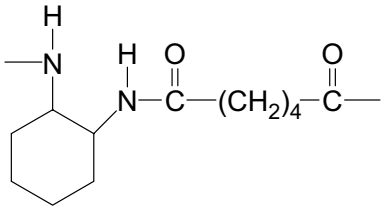
Question Number	Question		
22 (b) (iii)	State why $E^{\ominus}$ values cannot predict that a reaction will occur, only that it is possible.		
	Acceptable Answers	Reject	Mark
	High E_a so slow reaction / reactants are kinetically stable *IGNORE any mention of non-standard conditions*		1

Question Number	Question		
23 (a) QWC (i) & (iii)	Explain why poly(ethenol) is soluble in water.		
	Acceptable Answers	Reject	Mark
	Many –OH groups (1) which can hydrogen bond to water (1)		2

Question Number	Question		
23 (b) (i)	Draw the repeat unit of poly(ethenol)		
	Acceptable Answers	Reject	Mark
			2

Question Number	Question		
23 (b) (ii)	Write the formula of the monomer which polymerises to form poly(vinyl acetate), PVA.(poly(ethenylethanoate))		
	Acceptable Answers	Reject	Mark
			**3**

Question Number	Question		
23 (c) (i)	1,2-dibromocyclohexane reacts with ammonia to produce compound A, $C_6H_{14}N_2$. Give the structural formula of A.		
	Acceptable Answers	Reject	Mark
	 or displayed	$H_2NC_4H_6NH_2$	**1**

Question Number	Question		
23 (c)(ii)	Compound A reacts with hexanedioyl dichloride to produce a polymer. Draw the structure of the repeating unit of this polymer.		
	Acceptable Answers	Reject	Mark
	 link(1) rest of formula (1)	$—OC(CH_2)_4CONHC_6H_4NH—$ Amide link as CONH	**2**

Question Number	Question		
23 (c) (iii) QWC (i) & (iii)	Suggest why this polymer cannot be made into strong fibres.		
	Acceptable Answers	Reject	Mark
	Polymers do not form in an "unkinked" chain OR chain has bends at ring OR chain not linear OR strong fibres require straight chain (1) This polymer has fewer hydrogen bonds between chains (1)		**2**

Question Number	Question		
23 (d)	Classify the two polymerisation reactions.		
	Acceptable Answers	Reject	Mark
	Ethenol: Addition Fibre: Condensation		**1**

Section C

Question Number	Question		
24. (a) (i)	Define what is meant by a TRANSITION ELEMENT.		
	Acceptable Answers	Reject	Mark
	An element which forms ions in at least one of its compounds which have a partly filled shell of d electrons (1)		**1**

Question Number	Question		
24 (a) (ii) QWC (i) & (iii)	Explain the processes which lead to hydrated transition metal ions being coloured.		
	Acceptable Answers	Reject	Mark
	The water ligands split the d orbitals into one set at lower and one at higher energy (1) Light is absorbed (1) and the electron promoted to a higher level (1) The correct sequence must be given to score either of the last two marks	Any mention of light emitted scores zero	**3**

Question Number	Question		
24 (b) (i)	Give the formula of the red copper oxide which causes the red colour in glass.		
	Acceptable Answers	Reject	Mark
	Red Cu_2O (1)		**1**

Question Number	Question		
24 (b) (ii)	The production of red copper oxide is involved in a test for a functional group in organic chemistry. Name the reagent used in this test and the functional group it detects.		
	Acceptable Answers	Reject	Mark
	Benedicts/Fehlings (solution) (1) Accept recognisable phonetic spelling eg Felings, Benedicks, Benedikts Aldehyde (1)	Failings	**2**

Question Number	Question		
24 (c) QWC (i) & (iii)	Why would the addition of iron(II) oxide, FeO, or osmium(III) oxide, Os_2O_3, not replace aluminium ions in alumina?		
	Acceptable Answers	Reject	Mark
	FeO is 2+ not 3+ (1) Os^{3+} has too large a radius (1)		**2**

Question Number	Question		
24(d)(i) QWC (i-iii)	Starting with a chromium(III) compound, state how it could be converted into a chromium(VI) compound, a chromium(II) compound and a complex ion. You should include equations and colour changes in your answer.		
	Acceptable Answers	Reject	Mark
			7

	reagent	colour change	equation
(III)→(VI)	(1)	Green→orange-yellow (1)	(1)
(III)→(II)	(1)	Green→blue (1)	$Zn+2Cr^{3+}\rightarrow Zu^{2+}+2Cr^{2+}$ (1)
(III)→complex	(1)	(1)	(1)

<u>Reagent</u>

$E^{\ominus}$ for reagent must be more positive than 1.6 V

$E^{\ominus}$ for reagent must be more negative than -0.7 V. Do not allow a reducing agent that reacts with water.

<u>Colour change</u>
Do not penalise lack of green twice.

<u>Complex formation</u>
e.g. formation of $[Cr(NH_3)_6]^{3+}$
$[Cr(OH)_6]^{3-}$
$[Cr(en)_3]^{3+}$
$[Cr(edta)]^{-}$
$[Cr_2(Cu_3CO_2)_4\,(H_20)_2]$
$[Cr(CH_3CO_2)_4]$

Reagent and colour change must fit the complex

Score up to 7 marks (from the 9 marking points)

Question Number	Question		
24 (d) (ii) QWC (i-iii)	Discuss the chemistry of the use of chromium salts in breathalysers. Explain why they are no longer used and describe the chemistry of one modern type of breathalyser.		
	Acceptable Answers	Reject	Mark
	Breathalyser • Original contained dichromate/chromate ions which were reduced to green (chromium(III) by ethanol in breath (1) • Extent going green judgemental / chromium(VI) compounds carcinogenic (1) Then **Either** New one consists of a fuel cell (1) where ethanol oxidised by air (using a platinum catalyst) / Quantity of electricity proportional to amount of ethanol in breath (1) **Or** New one consists of an IR spectrometer (1) which measures line in fingerprint region / Amount of IR absorbed depends on amount of ethanol in breath (1)		**4**

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