Accredited

AS Level Chemistry A
H032/01 Breadth in chemistry
Sample Question Paper

Date – Morning/Afternoon
Version 2.1

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You may use:
- a scientific or graphical calculator

First name	
Last name	

Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **28** pages.

SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

1 How many electrons are in a ${}^{24}_{12}Mg^{2+}$ ion?

A 10

B 12

C 14

D 22

Your answer ☐

[1]

2 What is the formula of chromium(III) sulfate?

A Cr_3SO_4

B $Cr(SO_4)_3$

C $Cr_2(SO_4)_3$

D Cr_3SO_3

Your answer ☐

[1]

3 Which molecule is non-polar?

A SF_6

B H_2S

C PF_3

D NH_3

Your answer ☐

[1]

4 Which row is correct?

	Highest pH when added to water	Most reactive halogen
A	MgO	F_2
B	MgO	I_2
C	BaO	F_2
D	BaO	I_2

Your answer ☐

[1]

5 Which equation represents a redox reaction?

A $Mg + 2HCl \rightarrow MgCl_2 + H_2$

B $MgO + 2HCl \rightarrow H_2O + MgCl_2$

C $MgCO_3 + 2HCl \rightarrow CO_2 + H_2O + MgCl_2$

D $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

Your answer ☐

[1]

6 This question is about trends in the periodic table.

Which trend is correct?

A melting point decreases from lithium to carbon

B boiling point decreases from fluorine to iodine

C first ionisation energy decreases from lithium to caesium

D first ionisation energy increases from nitrogen to oxygen

Your answer ☐

[1]

7 A sample of a compound **M** contains 1.46 g of carbon, 0.482 g of hydrogen and 1.69 g of nitrogen.

What is the empirical formula of **M**?

A CH_2N

B C_4HN_4

C CH_4N

D C_2H_4N

Your answer ☐

[1]

8 A student mixes 100 cm^3 of 0.200 mol dm^{-3} NaCl(aq) with 100 cm^3 of 0.200 mol dm^{-3} Na_2CO_3(aq).

What is the total concentration of Na^+ ions in the mixture formed?

A 0.100 mol dm^{-3}

B 0.200 mol dm^{-3}

C 0.300 mol dm^{-3}

D 0.400 mol dm^{-3}

Your answer ☐

[1]

9 Which mass of substance contains the greatest number of atoms?

A 3.00 g of ammonia, NH_3

B 3.00 g of chloromethane, $CHCl_3$

C 4.00 g of hydrogen sulfide, H_2S

D 4.00 g of hydrogen chloride, HCl

Your answer ☐

[1]

10 Which reagent would exactly neutralise 100 cm^3 of 1.00 mol dm^{-3} $H_2SO_4(aq)$?

A 0.100 mol $Al(OH)_3$

B 0.100 mol NH_3

C 0.100 mol $Ba(OH)_2$

D 0.100 mol NaOH

Your answer ☐

[1]

11 The table below shows standard enthalpy changes of formation, $\Delta_f H$.

Compound	$NH_4NO_3(s)$	$H_2O(g)$	$CO_2(g)$
$\Delta_f \boldsymbol{H}$ **/ kJ mol**$^{-1}$	–366	–242	–394

What is the enthalpy change for the following reaction?

$$2NH_4NO_3(s) + C(s) \rightarrow 2N_2(g) + 4H_2O(g) + CO_2(g)$$

A –630 kJ mol^{-1}

B –540 kJ mol^{-1}

C +540 kJ mol^{-1}

D +630 kJ mol^{-1}

Your answer ☐

[1]

12 Carbon monoxide reacts with steam in the following reaction equation:

$$CO(g) + H_2O\ (g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -40\ \text{kJ mol}^{-1}$$

Which change will shift the position of equilibrium to the right hand side of the equation?

A decrease in pressure

B increase in pressure

C decrease in temperature

D increase in temperature

Your answer ☐

[1]

13 Which substance contains hydrogen bonding in the liquid state?

A $CH_3(CH_2)_4CH_3$

B $CH_3(CH_2)_3CHFCH_3$

C $CH_3(CH_2)_3COCH_3$

D $CH_3(CH_2)_3CH(OH)CH_3$

Your answer ☐

[1]

14 Which volume of oxygen gas, at room temperature and pressure, is required for complete combustion of 1.25×10^{-3} mol of propan-1-ol?

A 105 cm^3

B 120 cm^3

C 125 cm^3

D 135 cm^3

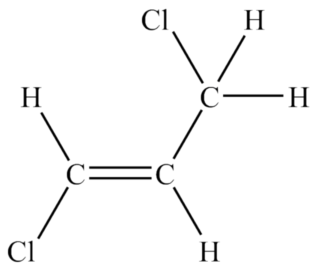
Your answer ☐

[1]

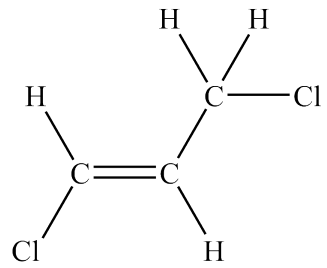
15 Three of the following displayed formulae represent the same isomer of $C_3H_4Cl_2$ but one structure represents a different isomer, **X**.

Which displayed formula represents **X**?

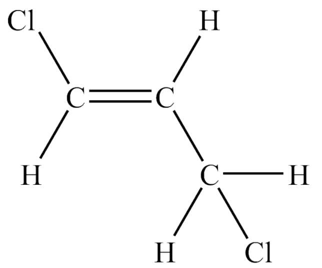
A



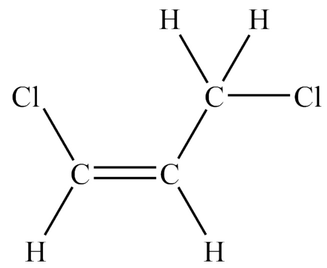
B



C



D



Your answer

[1]

16 Which alcohol will **not** react with potassium dichromate(VI) in sulfuric acid?

A $CH_3CH_2CH(OH)CH_2CH_3$

B $CH_3CH_2CH(CH_3)CH_2OH$

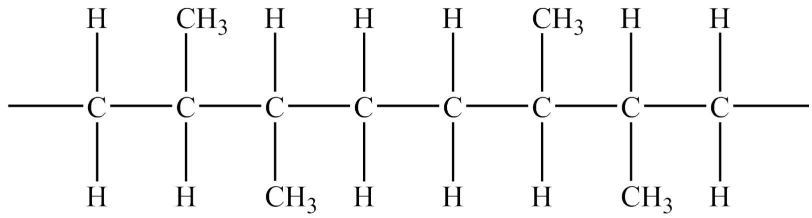
C $(CH_3)_2CHCH(CH_3)OH$

D $(CH_3CH_2)_2C(CH_3)OH$

Your answer

[1]

17 A section of a polymer chain is shown below.



Identify the monomer that would give rise to this section of addition polymer.

A *E*-But-2-ene

B *Z*-But-2-ene

C Methylpropene

D Propene

Your answer ☐

[1]

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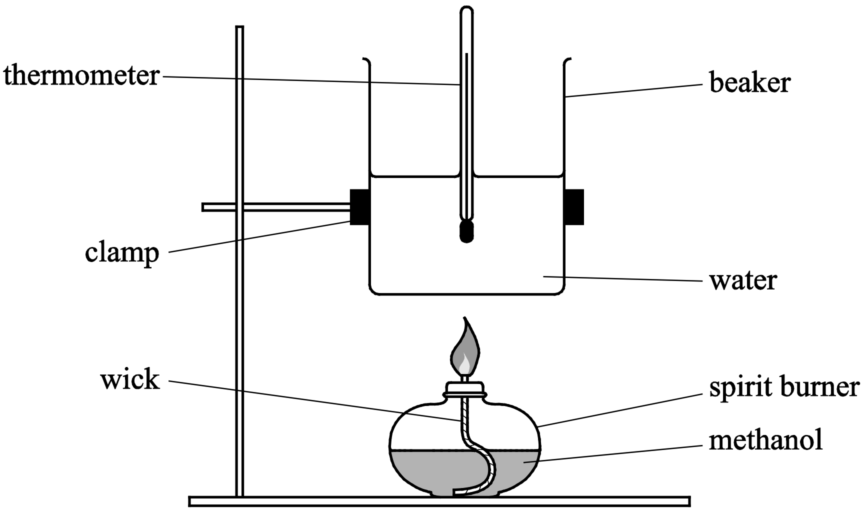
18 (a) A student used the apparatus below in an experiment to determine the enthalpy change of combustion of methanol.

The student measured 100 cm^3 and poured it into the beaker.



The student measured a temperature rise of 10.5 °C.

The student calculated the amount of energy transferred to the water.

Which of the following uses the appropriate number of significant figures and correct standard form to represent the result of the calculation?

A 4.389×10^3 J

B 4.39×10^3 J

C 43.9×10^2 J

D 44.0×10^2 J

Your answer ☐

[1]

18 (b) The student's calculated enthalpy change was less exothermic than the value in data books.

Which of the following errors could have contributed to this result?

Error 1: After the final temperature was recorded, the student removed the burner from under the beaker. The flame burnt for a further 5 minutes before weighing the spirit burner.

Error 2: The student recorded the final temperature 5 minutes after removing the burner.

Error 3: The student spilt some water on the bench when pouring the water from the measuring cylinder into the beaker.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

19 A student prepares a standard solution and carries out a titration.
The standard solution is placed in the burette.

Which of the following would result in a titre that is larger than it should be?

1: Water is added to completely fill the volumetric flask, rather than to the graduation line.

2: The conical flask is washed out with water before carrying out each titration.

3: The pipette is washed out with water before carrying out each titration.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

SECTION B

Answer **all** the questions.

20 Bromine and mercury are the only two naturally occurring elements that are liquids at room temperature and pressure. Some physical properties of these two elements are given below.

	Appearance at room temperature	Melting point / °C	Boiling point / °C	Electrical conductivity of the liquid
Bromine	dark orange liquid	–7.2	58.8	very low
Mercury	shiny silver liquid	–38.8	356.7	good

(a) Complete the full electron configuration of a bromine atom.

$1s^2$.. **[1]**

(b) Bromine and mercury react with many elements and compounds.

Predict the formula of the compound formed when bromine reacts with aluminium.

.... **[1]**

(c) Explain how the structure and bonding in bromine account for its relatively low melting point.

....

....

....

.... **[3]**

(d) Mercury and bromine react together to form mercury(II) bromide, $HgBr_2$.

Describe and explain how electrical conductivity occurs in mercury(II) bromide and mercury, in both solid and molten states.

....

....

....

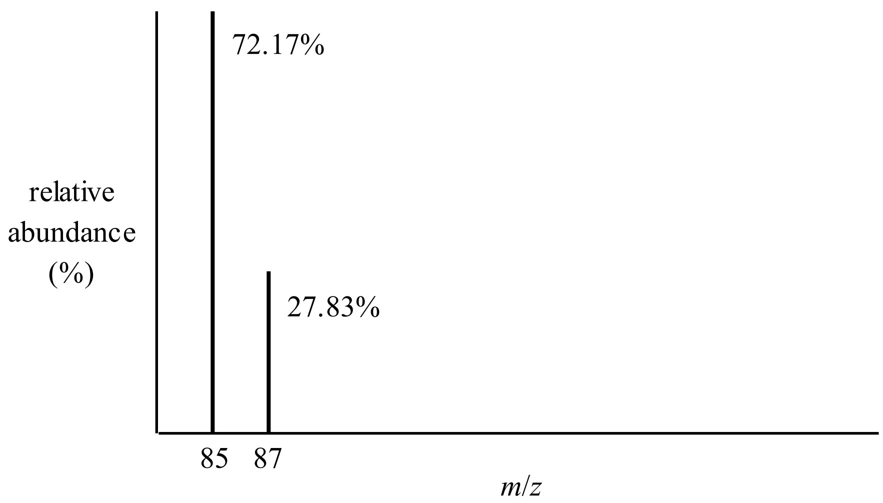
....

....

.... **[5]**

(e) Element **X** melts at temperatures reached on very hot summer days.

A sample of element **X** was analysed by mass spectrometry. The mass spectrum is shown below.



(i) Calculate the relative atomic mass of element **X**.

Give your answer to **two** decimal places.

relative atomic mass = ... **[2]**

(ii) Suggest the identity of element **X**.

.... **[1]**

21 Carbon monoxide can be made in the laboratory by heating a mixture of zinc metal and calcium carbonate. An equation for this reaction is shown below.

$$Zn(s) + CaCO_3(s) \rightarrow ZnO(s) + CaO(s) + CO(g)$$

(a) This reaction is a redox reaction.

Deduce which element has been oxidised and which has been reduced, and state the change in oxidation number in each case.

element oxidised .... oxidation number change: from ...... to ......

element reduced .... oxidation number change: from ...... to ......

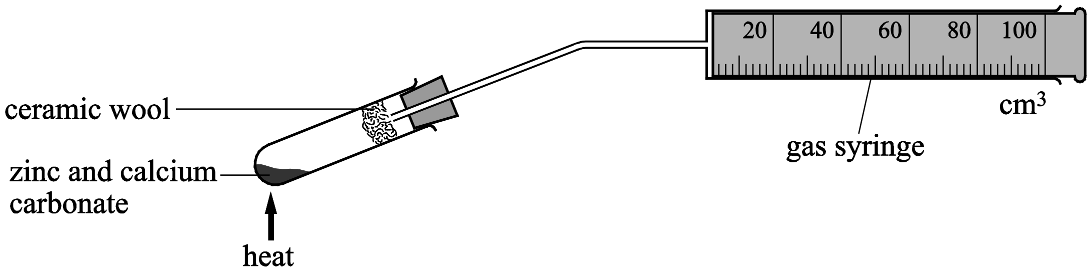
[2]

(b) Carbon monoxide contains a triple bond, and includes a dative covalent bond.

Construct a '*dot-and-cross*' diagram to show the outer electron pairs in a molecule of carbon monoxide.

[2]

(c) A student carried out the reaction of zinc (Zn) and calcium carbonate ($CaCO_3$) in a fume cupboard. The student measured the volume of gas produced.



A mixture containing 0.27 g of powdered zinc and 0.38 g of powdered $CaCO_3$ was heated strongly for two minutes. The volume of gas collected in the 100 cm^3 syringe was then measured. The experiment was then repeated.

(i) Calculate the maximum volume of carbon monoxide, measured at room temperature and pressure, that could be produced by heating this mixture of Zn and $CaCO_3$.

volume of carbon monoxide = ... cm^3 **[2]**

(ii) The student did **not** obtain the volume of gas predicted in **(i)** using this procedure.

Apart from further repeats, suggest **two** improvements to the practical procedure that would allow the student to obtain a more accurate result.

....

....

....

.... **[2]**

(d) The student repeated the experiment in **(c)** using different quantities of zinc and calcium carbonate.

The student measured the total volume of gas collected over time.

The student's results are shown below.

Time / s	**Total volume of gas collected / cm^3**
0	0
20	13
40	42
60	56
80	65
100	72
120	72

(i) Plot a graph from the data provided.

Include a line of best fit.

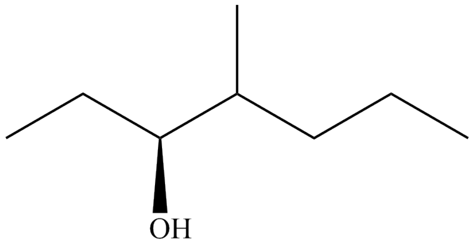
[3]

(ii) Using the graph, determine the rate of reaction, in $cm^3\ s^{-1}$, after 50 s.

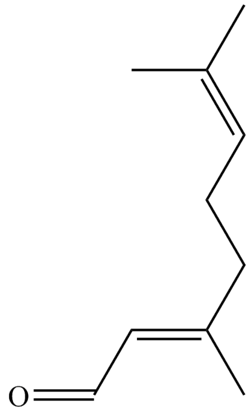
Show your working on your graph.

rate after 50 s = ……………………………. $cm^3\ s^{-1}$ **[2]**

22 The organic compounds labelled **A** to **E** below are all produced by living organisms.



A



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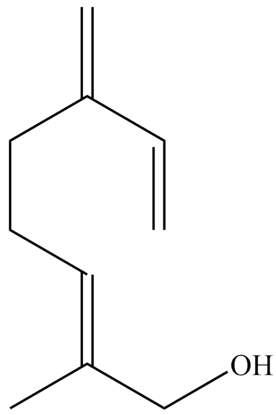
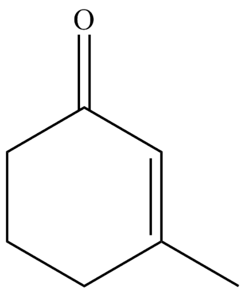
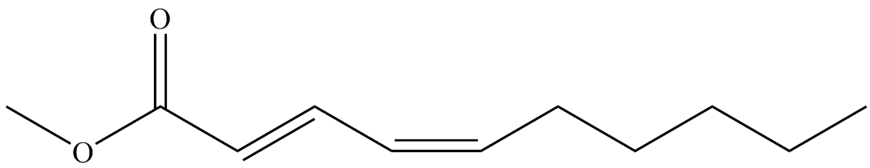


C



D



E

(a) State the systematic name of compound **A**.

.... **[1]**

(b) Compound **D** reacts readily with hydrogen chloride in an addition reaction. Two products are formed in this reaction, but one of the products is formed in much greater amounts than the other.

(i) Draw the structure of **both** possible addition products of this reaction.

product 1	**product 2**

[2]

(ii) State and explain which of the two possible products will be formed in greater amounts. Include a diagram of the intermediate in the mechanism of this reaction in your answer.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………….. **[2]**

(iii) 4.125 g of compound **D** is reacted with an excess of hydrogen chloride. The mixture of products contains 95% by mass of one product and 5% by mass of the other product.

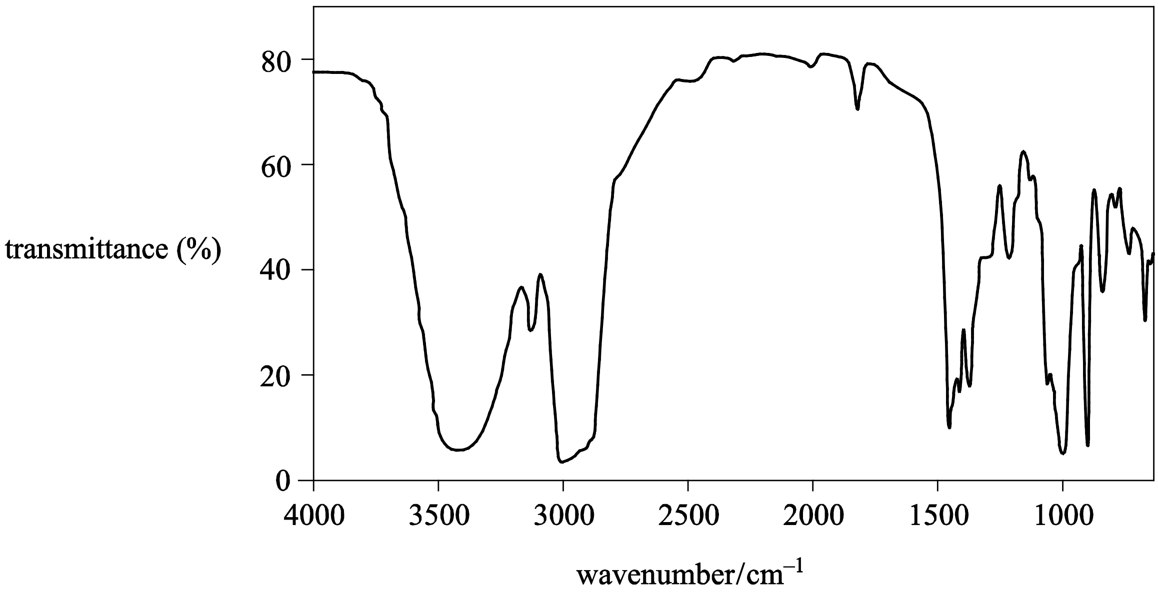
Calculate the mass of each product formed.

[2]

(c) Analysis of one of the compounds **A** to **E** is shown below.

Percentage composition by mass: C, 78.94%; H, 10.53%; O 10.53%

Infrared spectrum:



Use this information to identify the compound.

Explain your reasoning, referring to **all** the evidence provided.

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.... **[3]**

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23 A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by reaction of aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	**Observations**
1 cm^3 of hexane is mixed with 1 cm^3 dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm^3 dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

(a) **(i)** The reaction between aqueous sodium chlorate(I) and dilute hydrochloric acid produces aqueous sodium chloride as well as chlorine.

Suggest an equation for this reaction.

.... **[2]**

(ii) Outline a simple practical test that would confirm the presence of chloride ions in the lower layer, and give the expected result.

test: ....

result: ....

....

[2]

(iii) Name the apparatus that could be used to separate the two liquid layers present at the end of the experiment.

.... **[1]**

(b) The reaction of hexane with chlorine took place when the bright light was switched on.

(i) Give the skeletal formula of **one** possible organic product of this reaction.

[1]

(ii) Explain why this type of mechanism is likely to produce a mixture of organic products.

……………………………………………………………………………………………………..

……………………………………………………………………………………………… **[1]**

24 Every year, two million tonnes of ethanol are produced worldwide by hydration of ethene obtained from crude oil.

$$C_2H_4(g) \quad + \quad H_2O(g) \quad \rightleftharpoons \quad C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

This reaction is typically carried out using a catalyst at 300 °C and 6000 kPa.

(a) The catalyst allows the reaction to reach equilibrium more quickly at the given temperature and pressure.

(i) State the catalyst used in this reaction.

.... **[1]**

(ii) Outline how a catalyst increases the rate of a chemical reaction.

....

....

....

.... **[2]**

(b) An increasing amount of ethanol is made by the fermentation of glucose from plants, rather than by the hydration of ethene. Fermentation is catalysed by enzymes from yeast at a temperature of 40 °C and a pressure of 100 kPa.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Compare the sustainability of each process for the manufacture of ethanol, by considering their:

- atom economies
- raw materials
- reaction conditions.

Suggest which process is the more sustainable.

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.... **[4]**

END OF QUESTION PAPER

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Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

AS Level Chemistry A

H032/01 Breadth in chemistry

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70

This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. ‘can’t do’, ‘don’t know’)
   - OR if there is a mark (e.g. a dash, a question mark) which isn’t an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

11. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

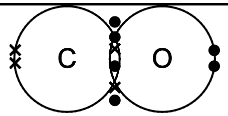
SECTION A

Question	Answer	Marks	Guidance
1	A	1	
2	C	1	
3	A	1	
4	C	1	
5	A	1	
6	C	1	
7	C	1	
8	C	1	
9	A	1	
10	C	1	
11	A	1	
12	C	1	
13	D	1	
14	D	1	
15	D	1	
16	D	1	
17	D	1	
18a	B	1	
18b	B	1	
19	D	1	
	Total	**20**	

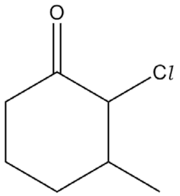
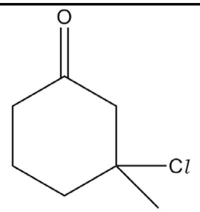
SECTION B

Question			Answer	Marks	Guidance
20	(a)		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$ ✓	1	**ALLOW** …$4s^2 3d^{10}$…
	(b)		$AlBr_3$ ✓	1	
	(c)		forces between (simple) molecules … ✓ … (which are) induced dipole–dipole forces **OR** London forces … ✓ … are weak, so (relatively easily) overcome by increased thermal motion/kinetic energy ✓	3	**IGNORE** any reference to covalent bonds **ALLOW** van der Waals' forces
	(d)		$HgBr_2$ conducts when molten but not when solid ✓ … because **ions** are mobile in molten $HgBr_2$ ✓ … but are fixed in a lattice in solid $HgBr_2$ ✓ Mercury conducts in both the solid and molten states … ✓ … because delocalised electrons move (in both solid and liquid state) ✓	5	Explanations **must** be included for 2nd and 3rd marks. **IGNORE** references to aqueous $HgBr_2$ **IGNORE** 'delocalised ions' **OR** 'free ions' for 'mobile ions' **DO NOT ALLOW** any mention of electrons moving **DO NOT ALLOW** any mention of + ions moving

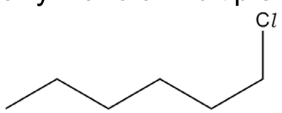
Question			Answer	Marks	Guidance
	(e)	(i)	$\frac{(85.00 \times 72.17) + (87.00 \times 27.83)}{2}$ ✓ = 85.56 (to 2 d.p.) ✓	2	
		(ii)	Rubidium **OR** Rb	1	
			Total	**13**	

Question			Answer	Marks	Guidance
21	(a)		Element oxidised: zinc/Zn 0 to +2 ✓ Element reduced: carbon/C +4 to +2 ✓	2	**ALLOW** 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around **max** 1 mark if missing '+' or 'if given as charges e.g. '2+'
	(b)		 three shared electron pairs plus a lone pair on C and O ✓ one of the shared pairs shown as dative – i.e. both with the same type of dot/cross as the other electrons around the O ✓	2	mark can be awarded if either lone pair is missing, but there must be three shared pairs
	(c)	(i)	*Determining limiting factor* *n*(Zn) 0.27/65.4 = 0.0041 mol **AND** *n*($CaCO_3$) = 0.38/100.1 = 0.0038 mol so Zn is in excess ✓ *<u>Determining volume of CO</u>* ratio 1:1, so *n*(CO) = 0.0038 (mol) vol. CO = 0.0038 x 24.0 = 0.091 dm^3 = **91** (cm^3) ✓	2	evidence of 0.27/65.4 is required (or using the mass ratio to predict 0.116g of CO from 0.27g Zn) or use of the mass ratio to predict 0.106g CO from 0.38g $CaCO_3$, and dividing by 28.0 to get 0.0038 mol CO **ALLOW** 2 sig figs up to calculator answer **ALLOW** second and third marks for correct final answer with no working **ALLOW** 2 marks for 99 cm^3 from excess Zn mass

Question			Answer	Marks	Guidance
		(ii)	heat until syringe stops moving/no further gas produced ✓ wait until the gas has cooled (to room temperature) before measuring the volume *owtte* ✓	**2**	**ALLOW** heat for longer than two minutes **ALLOW** heat a greater mass
	(d)	**(i)**	axes: labels correct, **AND** units **AND** scales chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions ✓ **ALL** points plotted correctly ✓ Best curve drawn through points **AND** ignoring point at 20 s ✓	**3**	
		(ii)	*Tangent* tangent drawn to curve at $t = 50$ s ✓ *Calculation of rate from the gradient of tangent drawn* e.g. rate = $\frac{64}{94}$ = 0.68 ($cm^3\ s^{-1}$) ✓	**2**	Annotate tangent on graph **Note**: This mark can only be awarded from a tangent **ALLOW ECF** for tangent drawn at different time from 50 s **ALLOW** ±10% of gradient of tangent drawn **ALLOW** 2 sig figs up to calculator value **ALLOW** trailing zeroes, e.g. 0.7 for 0.070 **IGNORE** '–' sign for rate **Note:** if candidate calculates rate via ln 2 method, consult with TL
			Total	**13**	

Question			Answer	Marks	Guidance
22	(a)		4-methylheptan-3-ol ✓	1	**ALLOW** 4-methyl-3-heptanol
	(b)	(i)	 ✓  ✓	2	**ALLOW** any unambiguous structure or formula **ALLOW ECF** on the second structure for hydrogen atom errors if candidate tries to convert to a displayed/structural formula, but the carbon skeleton must be correct
		(ii)	correct structure of either possible carbocation intermediate shown ✓ the tertiary halogenoalkane (which will be labelled as either product 1 or product 2) is identified as the one formed in greater amounts … because the carbocation more stable on C3 than C2 *owtte* ✓	2	If both carbocations are drawn, only one needs to be correct to score the mark **ALLOW ECF** from **(i)** for correct justification of product formed in greater amount based on incorrect structures
		(iii)	*Amount of **D** that reacts* M(**D**: $C_7H_{10}O$) = 110 (g mol^{-1}) **AND** $n(C_7H_{10}O) = \frac{4.125}{110} = 0.0375$ (mol) ✓ *Masses of two products formed* M(product: $C_7H_{11}OCl$) = 146.5 (g mol^{-1}) **AND** Mass of 95% product = $0.0375 \times \frac{95}{100} \times 146.5 = 5.22$ g **AND**	2	

Question			Answer	Marks	Guidance
			Mass of 5% product = $0.0375 \times \frac{5}{100} \times 146.5 = 0.27$ g ✓		**ALLOW** Mass of both products $= 0.0375 \times 146.5 = 5.49$ g Mass of 95% product = $\frac{95}{100} \times 5.49 = 5.22$ g Mass of 5% product = $\frac{5}{100} \times 5.49 = 0.27$ g **ALLOW** 'product 1' and 'product 2' if linked to **correct** mass given labelling in **(i)** and reasoning in **(ii)** (**ALLOW ECF** from **(ii)**).
	(c)		(broad) peak at 3300–3600 (cm^{-1}) for O–H (therefore A or C) ✓ molar ratio: C : H : O $\frac{78.94}{12.0} : \frac{10.53}{1.0} : \frac{10.53}{16.0}$ **OR** 6.58 : 10.53 : 0.658 ✓ 10 : 16 : 1 **OR** $C_{10}H_{16}O$, therefore C ✓	3	**ALLOW** 3200–3600 cm^{-1} **IGNORE** references to the peak at ~2900 for C–H **ALLOW** annotation of the spectrum to identify the bond responsible for the peak instead of quoting the wavenumber Conclusion may also follow from empirical formula followed by IR data.
			Total	**10**	

Question			Answer	Marks	Guidance
23	(a)	(i)	$NaClO + 2HCl \rightarrow NaCl + Cl_2 + H_2O$ correct formulae of reactants, NaCl and chlorine ✓ water and balancing ✓	2	**ALLOW** $NaClO_3 + 6HCl \rightarrow NaCl + 3Cl_2 + 3H_2O$ for 1 mark
		(ii)	Test: add (a few drops of aqueous) silver nitrate ✓ Result: white ppt ✓	2	**IGNORE** addition of dilute nitric acid before the $AgNO_3$ **IGNORE** redissolving in excess NH_3 or darkening of the ppt
		(iii)	separating funnel ✓	1	**ALLOW** dropping pipette
	(b)	(i)	any mono or multiple substituted chlorohexane – e.g.  ✓	1	
		(ii)	(because) substitution can replace any H atom / multiple substitution *owtte* ✓	1	**IGNORE** vague statements about free radical reactions being random **ALLOW** termination can join alkyl radicals to form larger hydrocarbons *owtte*
			Total	7	

Question			Answer	Marks	Guidance
24	(a)	(i)	phosphoric acid / H_3PO_4 ✓	1	if both name and formula are given, the formula must be correct, but **ALLOW** minor errors in an attempt at the name
		(ii)	(allows the reaction to proceed via a route with) lower activation energy … ✓ … so that a greater proportion of molecules exceed the activation energy ✓	2	**ALLOW** a sketch of an energy profile diagram as long as the catalysed and uncatalysed E_a are both labelled **ALLOW** 'more molecules exceed the activation energy' **ALLOW** a sketch of a Boltzmann distribution as long as both axes and both E_a values are labelled
	(b)		atom economy suggests hydration is more sustainable ✓ (but …) ***Any two from:*** the CO_2 given off is taken in by plants as they grow ✓ (ethene from) crude oil is non-renewable/glucose is renewable ✓ fermentation does not require high temperatures/ pressures, so lower energy demand ✓ so on balance fermentation is more sustainable *owtte* ✓	4	**IGNORE** references to global warming or 'carbon neutral' There must be a conclusion for this mark
			Total	7	

Summary of updates

Date	Version	Change
January 2019	2.0	Addition to the rubric clarifying the general rule that working should be shown for any calculation questions.
February 2021	2.1	Correction and reordering of Q14 answer options and corresponding amendment to mark scheme.

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