GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2012 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

CH1

Section A

1. 

[1]

2. $1/12^{th}$ mass of one atom of carbon-12. [1]

3. C [1]

4. (a)

C	O	Cl	
$\frac{12.1}{12}$	$\frac{16.2}{16}$	$\frac{71.7}{35.5}$	(1)
1.01	1.01	2.02	
1	1	2	

Formula = $COCl_2$ (1) [2]

(b) M_r / molecular mass / number of atoms of any element in compound [1]

5. (a) **C B D E A** [2]

(1 mark if one mistake e.g. **A** in wrong place)

(b) **Z** (1)

Si is in Group 4 therefore large jump in ionisation energy would be after the fourth ionisation, not before it / **W**, **X** and **Y** have a large jump before the fourth ionisation energy so cannot be in Group 4 (1)

[2]

Total [10]

Section B

6. (a) (i) 12 [1]

(ii) 14 [1]

(iii) Percentage / abundance / ratio / proportion of each isotope [1]

(b) (i) 0.125 g [1]

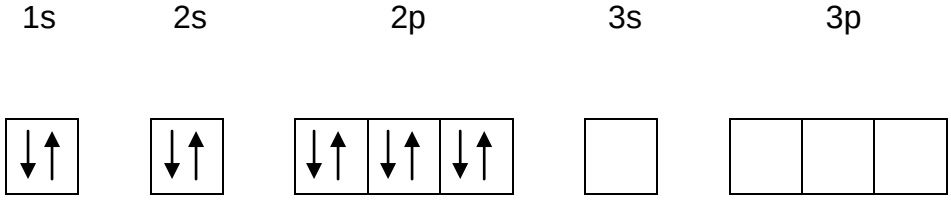
(ii) e.g. Cobalt-60 (1) in radiotherapy (1) / Carbon-14 (1) in radio carbon dating (1) / Iodine-131 (1) as a tracer in thyroid glands (1) [2]

(c) (i) Atoms are hit by an electron beam / electrons fired from an electron gun (and lose electrons) [1]

(ii) To be able to accelerate the ions (to high speed) / so that they can be deflected by a magnetic field
- no credit for 'so that *atoms* can be deflected…' [1]

(iii) They are deflected by a magnetic field / according to the m/z ratio [1]

(d)



[1]

(e) (i) $Mg_3N_2 + \mathbf{6}H_2O \longrightarrow \mathbf{3}Mg(OH)_2 + \mathbf{2}NH_3$ [1]

(ii) moles $Mg(OH)_2$ = 1.75/58.32 = 0.0300 (1)

moles Mg_3N_2 = 0.0100 (1)

mass Mg_3N_2 = 0.01 x 100.9 = 1.01 g (1) [3]

- must be **3 significant figures** to gain third mark

Total [14]

7. (a) Plotting (2)

Best fit line (1) [3]

(b) (i) C (1)

Curve steeper (1) [2]

(ii) Concentration of acid is greatest [1]

(c) 44 cm^3 (±1 cm^3) [1]

(d) Moles Mg = 0.101/24.3 = 0.00416 (1)

Moles HCl = 2 x 0.02 = 0.04 (1) [2]

(e) (i) Mg is not the limiting factor /

Mg now in excess / HCl not in excess [1]

(ii) Moles acid = 0.5 x 0.04 = 0.02 (1)

Volume H_2 = 0.01 x 24 = 0.24 dm^3

- correct unit needed (1) [2]

(f) Lower the temperature of the acid (1)

Reactants collide with less energy (1)

Fewer molecules that have the required activation energy (1) [3]

or Use pieces of magnesium (1) less surface area (1) less chance of successful collisions (1)

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter. [1]

Total [16]

8. (a) Oil is non-renewable / will run out (1)

Contribution of CO_2 to global warming (1)

Oil has other important uses (1) [2]

(Maximum 2 marks)

(b) (i) Power stations / fossil fuels used to generate the electricity needed to make H_2 (1)

Resulting in CO_2 formation (global warming) / acid rain (1)

Manufacture of car produces pollution (1) [2]

(Maximum 2 marks)

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(ii) Disagree, no fuel is 100% safe /
petrol can burn explosively
(Accept agree if valid reason given e.g. in terms of lives being lost) [1]

(c) (i) Hydrogen since frequency is inversely proportional to wavelength / smaller wavelength [1]

(ii) Hydrogen since energy is proportional to frequency / greater frequency / E = hf [1]

(d) In Ne greater shielding of *outer* electron (1) outweighs larger nuclear charge (1) / He has greater effective nuclear charge (1) / He *outer* electron closer to nucleus (1)
- max 1 if no reference to *outer* electron [2]

(Maximum 2 marks)

(e) (i) ^{218}Po [1]

(ii) Since radon is a gas / inhaled, α particles will be given off in the lungs (which may cause cancer) [1]

Total [12]

9. (a) Low temperature (1)
As temperature is decreased equilibrium moves in exothermic direction. (1)

High pressure (1)

As pressure is increased equilibrium moves towards side with smaller number of gas moles (1) [4]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(b) ΔHreaction = ΔH_f products – ΔH_f reactants (1)

-46 = ΔH_f ethanol – (52.3 – 242)

ΔH_f ethanol = -46 – 189.7 (1)

ΔH_f ethanol = -235.7 kJ mol^{-1} (1) [3]

(c) Bonds broken = 1648 + 612 + 926 = 3186 kJ mol^{-1} (1)

Bonds formed = 2060 + 348 + 360 + 463 = 3231 kJ mol^{-1} (1)

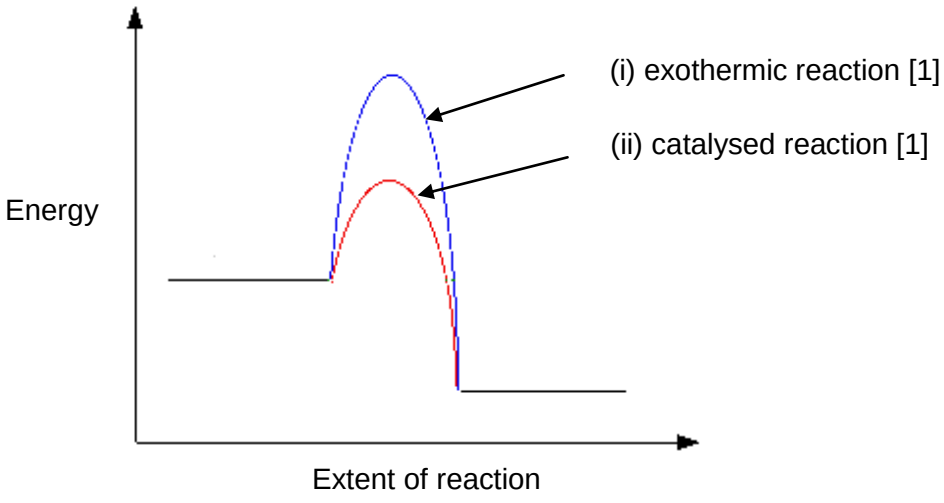
ΔH reaction = 3186 – 3231 = -45 kJ mol^{-1} (1)
[3]

(d) (i) Average bond enthalpies used (not actual ones) [1]

(ii) Yes, since answers are close to each other [1]

(e) Catalyst is in different (physical) state to reactants [1]

(f)



Total [16]

10. (a) Weighing bottle would not have been washed / difficult to dissolve solid in volumetric flask / final volume would not necessarily be 250 cm^3 [1]

(b) Pipette [1]

(c) To show the end point / when to stop adding acid / when it's neutralised [1]

(d) So that a certain volume of acid can be added quickly before adding drop by drop / to save time before doing accurate titrations / to give a rough idea of the end point [1]

(e) To obtain a more reliable value [1]

(f) (i) Moles = 0.730/36.5 = 0.0200 (1)

Concentration = 0.02/0.1 = 0.200 mol dm^{-3} (1) [2]

(ii) Moles = 0.2 x 0.0238 = 0.00476 [1]

(iii) 0.00476 [1]

(iv) 0.00476 x 10 = 0.0476 [1]

(v) M_r = 1.14/0.0476 = 23.95 [1]

(vi) Lithium [1]

- mark consequentially throughout (f)

Total [12]

Section B Total [70]

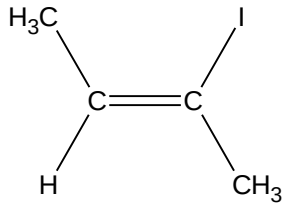
SECTION A

Q.1 (a) $C_{19}H_{40}$ [1]

(b) $C_{19}H_{40} \rightarrow C_8H_{18} + C_{11}H_{22}$ - allow ecf [1]

Q.2 2-chlorobutane [1]

Q.3 [1]



Q.4 any number in range 1 to 6 [1]

Q.5 (a) maximum mass = 44-45 (g) [1]

(b) (less solute would form as a solid) because more will remain in the solution [1]

Q.6 (a) iodine force is Van der Waals/ induced dipole-induced dipole (1)

diamond force is covalent bond/ description of attractive forces in a covalent bond (1) [2]

(b) diamond would have a higher sublimation temperature because it has strong**er** forces/ forces are hard**er** to break [1]

Section A Total [10]

SECTION B

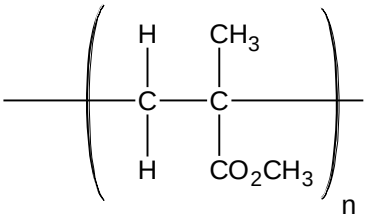
Q.7 (a) (i) one σ bond/ description of σ bond/ diagram to show overlap of s orbitals (1)

one π bond/ description of π bond/ diagram to show sideways overlap of p orbitals (1)

[2]

(ii) joining of **many/lots of** (small) units or many alkenes / molecules to make a **large/long** unit/ molecule [1]

(iii)



[1]

(iv) C_4H_5Cl [1]

(b) (i) BF_3 is planar triangular/ trigonal planar (1)

NH_3 is pyramidal/ trigonal pyramid (1) [2]

(ii) BF_3 has 3 bond pairs (1)

NH_3 has 3 bond pairs and 1 lone pair (1) [2]

QWC the information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(c) (i) co-ordinate/ dative covalent/ dative
- no credit for 'covalent' [1]

(ii) 109½° (accept any in range 109°-110°) [1]

(iii) 4 bond pairs/ bonds (around B)
- no credit for 'tetrahedral' [1]

Total [13]

Q.8 (a) (i) % H = 14.3 (1)

$$C : H = \frac{85.7}{12.0} : \frac{14.3}{1.01} = 7.14 : 14.16 \text{ (1)}$$

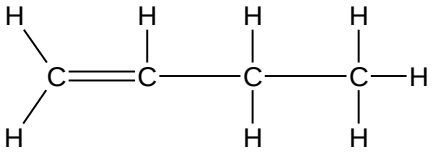
empirical formula = CH_2 (1) [3]

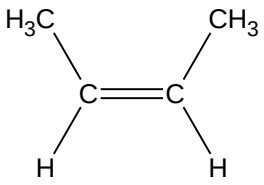
(ii) M_r = 42/ largest fragment has mass 42 (1)

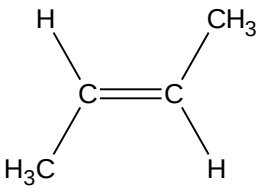
(CH_2 = 14) therefore molecular formula = C_3H_6 (1) [2]

(iii) CH_3 is present [1]

(b) 1 mark for each [3]







Total [9]

Q.9 (a) apparatus in which reaction can occur, e.g. flask/ test tube, and delivery/ rubber tube (1)

apparatus in which to measure volume of gas, e.g. over water with measuring cylinder/ gas syringe (1) [2]

(b) (i) fewer **moles** of barium used / barium has a higher A_r [1]

(ii) reaction faster/ more vigorous/ less cloudy solution formed with barium (1)

because ionisation energy of barium is less/ electrons lost more easily from barium/ barium is lower in the group/
barium hydroxide is more soluble (1) [2]

(c) flame test (1) brick red for calcium **and** (apple) green for barium (1)

OR

add sulfuric acid/ sodium sulfate solution/ potassium sulfate solution (1)

white precipitate with Ba^{2+}, less precipitate/ no precipitate with Ca^{2+} (1) [2]

(d) electrons correct – oxide ion clearly shows that 2 electrons originated from calcium atom (1)
charges correct (1) [2]

(e) (i) add sulfuric acid/ sodium sulfate solution/ potassium sulfate solution (1)

filter (1)

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ (1)

- state symbols ignored [3]

(ii) moles Ba = 2/137 (1)

mass $BaSO_4 = \frac{2 \times 233.1}{137} = 3.4$ (g) (1) [2]

Total [14]

Q.10 (a) both contain metallic bonds/ positive ions and delocalised electrons labelled on diagram (1)

those in magnesium are stronger/ harder to break/ need more energy to break (1)

because **2** electrons are involved in delocalisation/ attraction to the positive ions (1) [3]

(b) reaction is hydrolysis of halogenoalkane/ nucleophilic substitution of halogenoalkane (1)

$C_4H_9X + OH^- \rightarrow C_4H_9OH + X^-$ X can be Cl or Br (1)

(white precipitate is) silver chloride and (cream precipitate is) silver bromide (1)

$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$ or $AgNO_3 + X^- \rightarrow AgX + NO_3^-$ (1)

- state symbols ignored [4]

QWC selection of form and style of writing appropriate to purpose and to complexity of subject matter [1]

(c) caesium ions are bigger than sodium ions – accept 'atoms' (1)

co-ordination number 6 : 6 for sodium and 8 : 8 for caesium (1)

both cubic (1) [3]

(d) reaction is electrophilic addition (1)

two possible products are 1-bromopropane and 2-bromopropane (1)

more 2-bromopropane formed (1)

because of greater stability of intermediate positive ion/ 2° carbocation (1)
[4]

QWC legibility of text; accuracy of spelling, grammar and punctuation, clarity of meaning [1]

Total [16]

Q.11 (a) diagram completed with at least 1 water molecule and indication of interaction between O on one molecule and H on the other (1)

interaction between δ^+ on H and lone pair on O (1)

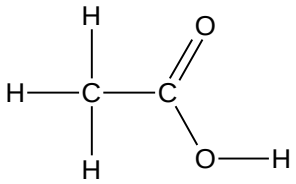
interaction labelled hydrogen bond (1) [3]

(b) (i) reduction/ redox – accept 'oxidation' [1]

(ii) I OH [1]

II OH is also present in water [1]

(c) (i) [1]



(ii) peak at 1650-1750 (1)

due to C=O (1) [2]

Total [9]

Q.12 (a) incomplete p sub-shell/ outer electron configuration s^2p^5/ outer electrons in p subshell/ outer electrons in p orbitals/ valence electrons in p subshell/ valence electrons in p orbital [1]

(b) (i) gaining one electron completes shell/ gives p^6/ takes an electron from another species/gains an electron

- do not accept 'attracts an electron' [1]

(ii) **fluorine** because it is the smallest/ has the greatest electron affinity/ has the least shielding/ has the greatest effective nuclear charge/ oxidising power decreases as the group is descended

[1]

(c) oxidation state is (+)5/ V

- do not accept '5+' [1]

(d) (i) $Cl_2 \rightarrow 2Cl^{\bullet}$ - ignore hf

[1]

(ii) $CH_4 + Cl^{\bullet} \rightarrow HCl + {}^{\bullet}CH_3$ (1)

${}^{\bullet}CH_3 + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ (1) [2]

(e) products: ${}^{\bullet}CFH_2$ and $Cl^{\bullet}$ (1)

C-**Cl** bond is the weak**est**/ **most** easily broken (1) [2]

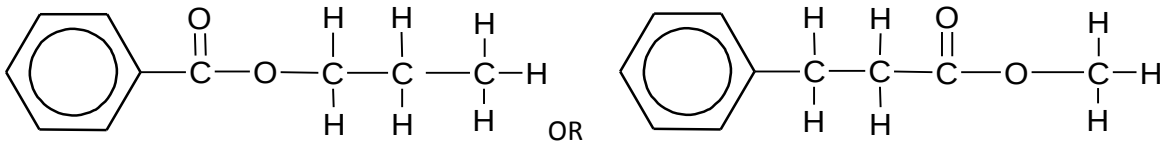
Total [9]

Section B Total [70]

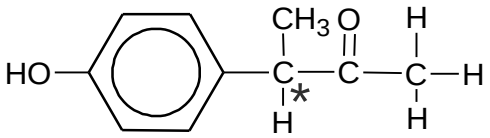
Question 1

(a) Any valid ester structure with formula $C_{10}H_{12}O_2$ [1]

Examples:



(b) (i) Compound X [1]

(ii)  [1]

(iii) Rotate the plane of polarised light in opposite directions [1]

(c)

Reagent(s)	*Observation if the test is positive*	*Compound(s) that would give a positive result*
I_2 / NaOH (aq)	Yellow solid	X
Na_2CO_3 (aq)	Bubbles of colourless gas / effervescence	W
$FeCl_3$ (aq)	Dark purple/blue/green - do not accept 'precipitate'	X, Z

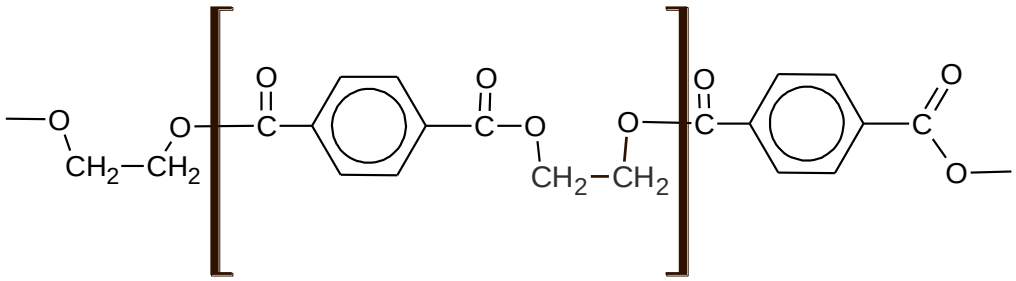
(*1 mark for each box*) [6]

(d) (i) Heat / Alkaline / Potassium manganate(VII) / then acidify
(1 mark for Potassium manganate + 1 other point; 2 marks for all) [2]

(ii) I. Addition polymer – One large molecule formed only / Condensation polymer – one large molecule with small molecules (e.g. water) lost. (1)

Addition polymer – one starting material / Condensation – two starting materials
OR Addition polymer – one functional group in each molecule/ Condensation polymer – two functional groups in each molecule (1) [2]

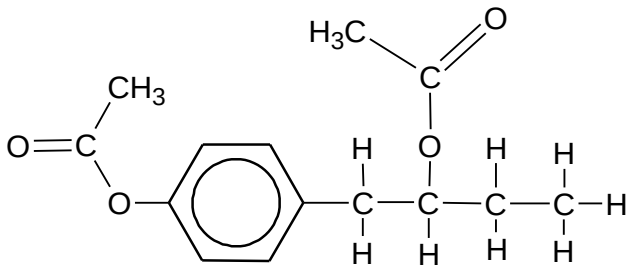
II.



[1]

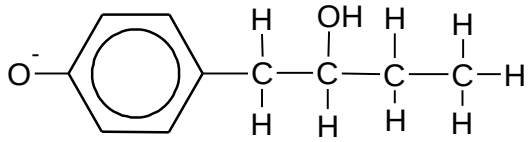
(e) (i) $NaBH_4$ / $LiAlH_4$ or name(1) Reduction (1) [2]
- ignore conditions unless $LiACH_4$ in water
- do not accept 'redox'

(ii)



Accept structures with only one –OH group reacted. [1]

(iii) [1]



[19 marks]

Question 2

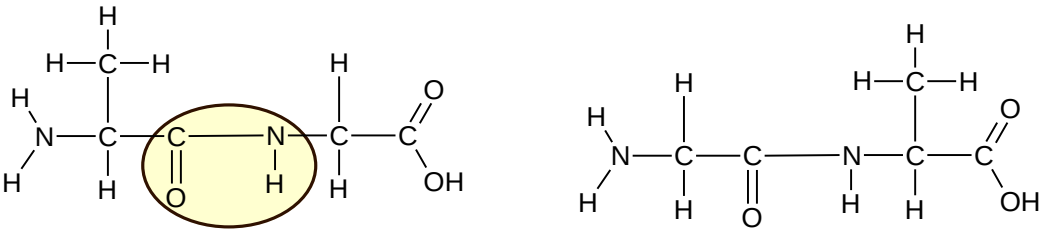
(a) (i) Alanine forms a zwitterion (1)

Forces between alanine molecules are ionic bonding (1)

Ionic bonding much stronger than hydrogen bonding / van der Waals (1)

Max 2 marks [2]

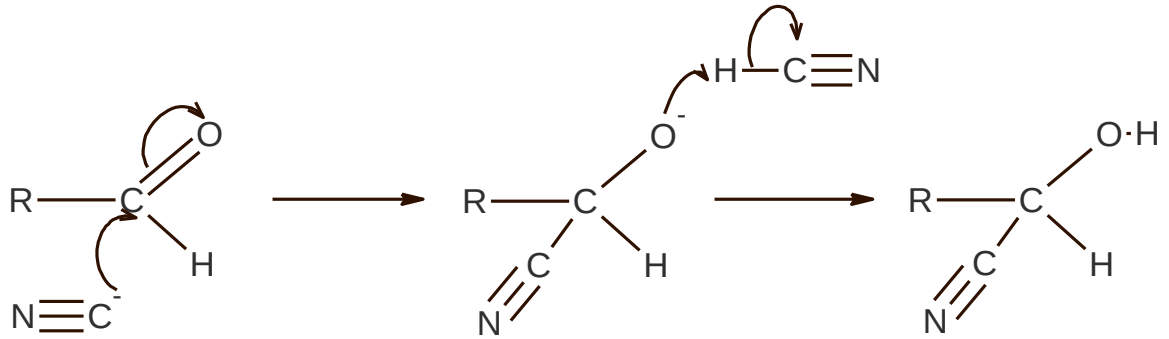
(ii) 1 mark for each correct structure [2]



(iii) 1 mark for correct identification of peptide link [1]

(b) Enzymes / Structural proteins / Hormones or specific example [1]

(c) 1 mark for arrows in first stage; 1 mark for correct intermediate; 1 mark for arrow giving gain of proton in second stage (from HCN or from H^+).



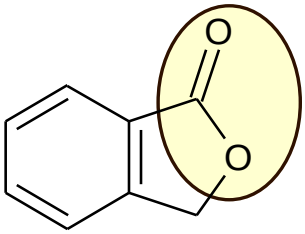
[3]

(d) Soda lime [1]

[10 marks]

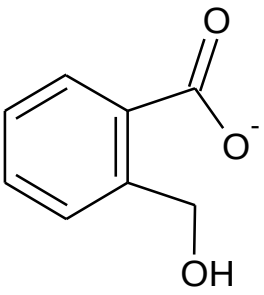
Question 3

(a) (i) [1]



Phthalide

(ii) [1]



(b) Distillation / Chromatography [1]

(c) Hydrogenation of 3-butyl phthalide removes a benzene ring (1)
Benzene ring is more stable than alkene/ Reference to delocalisation energy (1) [2]

(d) 62.1% [1]

(e) (i) Greater variety of different phthalides that can be produced [1]

(ii) Higher atom economy / less waste / carbon monoxide is toxic [1]
- do not accept references to yield

(f) Silver nitrate and ammonia / Tollen's reagent (1); Q = Silver mirror (1); R = No reaction (1)
OR 2,4,-DNP (1); Orange precipitate with Q (1); No reaction with R (1)
OR Fehling's solution (1); Orange solid with Q (1); No reaction with R (1) [3]

[11 marks]

Question 4

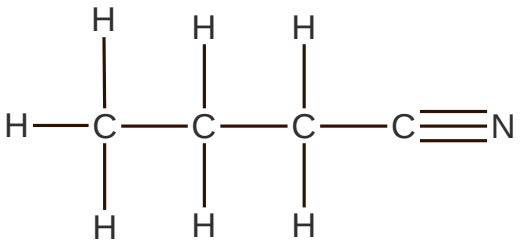
(a) (i) Nucleophilic substitution / Hydrolysis [1]

(ii) Dissolved in alcohol (1) Propene or unambiguous structure (1) [2]

(iii) Potassium manganate(VII) / Potassium dichromate(VI) - must be **name** (1)
Oxidation (1) [2]

(iv) (Add Potassium dichromate(VI)) and distil off the propanal from the reaction mixture [1]

(b) (i) Step 1: Potassium cyanide in ethanol / Heat (1)
Step 2: Heat with aqueous hydrochloric acid (or other acid) (1)



(1) [3]

(ii) Two points from different bullet points – 1 mark each.

- Atom economy / Amount of waste / Whether waste material was recyclable / Whether waste was toxic.
- Amount of energy required / temperature required / pressure required / conditions used
- Rate of production / time
- Availability of catalyst
- Cost of reactants / Availability of reactants / toxicity of reactants.
- Two step processes usually have lower yields than one step processes / percentage yield [2]
- Purification method / separation

(c) (i) Butanoic acid is $C_4H_8O_2$ so $M_r = 88$ (1)
Percentage carbon = 48/88 x 100 = 54.5%; percentage hydrogen = 8/88 = 9.1%;
Percentage oxygen = 32/88 = 36.4% (At least two of these for 1)
OR empirical formula for butanoic acid = C_2H_4O (1) and
calculate empirical formula from percentage masses = C_2H_4O (1) [2]

(ii) Structure 1 mark + 4 marks for explanations.

- Product is ethyl ethanoate. (1)
- Two points from the following required for each mark– MAX 4 marks
  - Sweet-smelling = ester
  - Peak at 1.0ppm implies – CH_3
  - Peak area 3 = CH_3
  - Peak area 2 = CH_2
  - Triplet shows CH_3 is next to a CH_2 group.
  - Singlet shows CH_3 no hydrogen atoms bonded to adjacent carbon.
  - Peak at 2.1 ppm suggests this is next to C=O.
  - Quartet shows CH_2 is adjacent to a CH_3 group.
  - Peak at 4.0 ppm shows it is –O-CH_2-
  - IR Peak at 1752 cm^{-1} = C=O
  - IR Peak at 2981 cm^{-1} = C-H or O-H
  - Cannot be –OH as we know there is no –OH in NMR spectrum

[5]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter. (1)

QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate. (1) [2]

[20 marks]

Question 5

(a) (i) (Concentrated) nitric acid / (concentrated) sulfuric acid / Temperature of 40-80°C
(*Any 2 = 1 mark; All 3 = 2 marks*)
Electrophilic substitution (1) [3]

(ii) I. Peak area is proportional to amount of substance (1)
Percentage = (30 / 38) x 100 = 79% (1)
(Can obtain both marks from correct percentage) [2]

II. 45 = $COOH^+$, 46= NO_2^+, 122 = $C_6H_4NO_2^+$ and 167 = $C_7H_5NO_4^+$.
(*Any 2 = 1 mark; All 4 = 2 marks*) [2]

(iii) I. Lower melting point / melts over a range [1]
II. 1 mark for each point.

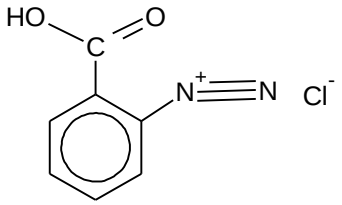
- Dissolve in the minimum volume
- Of hot water
- Filter hot
- Allow to cool
- Filter
- Dry residue under suction / in oven below 142°C

Max 4 marks [4]

QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning.[1]

(b) (i) Tin and concentrated hydrochloric acid [1]

(ii) Below 10°C (1)



(1) [2]

(iii) N=N double bond is chromophore (1)
Compound absorbs blue /green / complementary colours to red / all colours but red (1)
Remaining frequencies are transmitted, giving the red colour seen. (1)
Any 2 out of 3 [2]

(c) Nitrogen has a lone pair (1) which can accept a proton (1) [2]

[20 marks]

SECTION A

1. (a) 1 dm^3 at 20°C contains 52.9 g and at 0°C it contains 17.5 g (1)
∴ amount crystallised = 52.9 – 17.5 = 35.4 g (1) [2]

(b) (i) 2 mol of $K_2S_2O_8$ give 1 mol of O_2
2 mol of $K_2S_2O_8$ give 29.0 dm^3 of O_2 (1)
∴ 0.1 mol of $K_2S_2O_8$ gives 29.0/20 = 1.45 dm^3 of oxygen (1) [2]

(ii) Measure the volume of oxygen produced at specified time intervals /
Measure the pH of the solution at specified time intervals [1]

(c) (i) An (inert) electrode that is used to carry the charge / current / electron flow [1]

(ii) A comment on the relative values (e.g. the persulfate system is the more positive of the two systems) (1)
The more positive 'reagent' / persulfate ions acts as the oxidising agent, accepting electrons via the external circuit (1)
- must have the first mark to get second [2]

(d) (i) The experiments show that both the concentrations of iodide and persulfate have doubled (1) therefore the initial rate should increase four times
$4 \times 8.64 \times 10^{-6} = 3.46 \times 10^{-5}$ (1) [2]

(ii) Rate = $k [S_2O_8^{2-}] [I^-]$ (1)

$$\therefore \quad k = \frac{8.64 \times 10^{-6}}{0.0400 \times 0.0100}$$

= 0.0216 (1) $dm^3\ mol^{-1}\ s^{-1}$ (1) [3]

(iii) In the rate equation one $S_2O_8^{2-}$ ion reacts with one I^- ion.
The rate-determining step therefore has to have 1 mole of each reacting, as (only) seen in step 1 [1]

Total [14]

2. (a) - 705 (kJ mol^{-1}) (1) for correct sign (1) for correct number [2]

(b) (i) ……. hydration ……

…….. lattice **breaking** [1]

(ii) e.g. add a small 'amount' of an alkali / sodium hydroxide / NaOH / OH^- ions (1)
this would remove / react with hydrogen ions giving water, shifting the position of equilibrium to the left (removing iodine) (1)
add $P6^{2+}$ / Ag^+ ect. [2]

(c) (i) Any TWO from
white / misty fumes (of HI)
yellow solid / solution (of sulfur)
brown / black solid / purple vapour (of iodine)
bubbles / effervescence / fizzing

One mark for each correct response [2]

(ii) The values show that chlorine is the best oxidising agent, as it has the most positive E^θ value and therefore iodide is the better reducing agent (1)
and is 'strong' enough to reduce the sulfuric acid. / OWTTE (1) [2]

(d) (i) $2\ NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2O$ [1]

(ii) e.g. bleach, kills bacteria [1]

Total [11]

3. (a) (i)

Number of moles of EDTA = $\frac{19.20 \times 0.010}{1000}$ = 1.92×10^{-4} / 0.000192 [1]

- error carried forward throughout (a)

(ii) 1.92×10^{-4} / 0.000192 [1]

(iii) Concentration = $\frac{1.92 \times 10^{-4} \times 1000}{50}$ = 3.84×10^{-3} / 0.00384 mol dm^{-3} (1)

Concentration = $3.84 \times 10^{-3} \times 63.5$ = 0.244 g dm^{-3} (1) [2]

(iv) % Cu = $\frac{0.244 \times 100}{11.56}$ = 2.11 [1]

(b) Transition elements have either a partly filled 3d sub-shell or form ions that have a partly filled 3d sub-shell (1)
However copper forms Cu^{2+} ions that are '$3d^9$' / partly filled 3d sub-shell (1)
whereas Zn^{2+} ions are '$3d^{10}$' / full 3d sub-shell (1) - any 2 from 3 [2]

QWC Organisation of information clearly and coherently; use of specialist vocabulary where appropriate. [1]

(c)

Complex ion	Shape	Colour
$[CuCl_4]^{2-}$	tetrahedral	yellow / lime green
$[Cu(NH_3)_4(H_2O)_2]^{2+}$	octahedral	deep blue

Any two correct (1) all correct (2) [2]

(d) The more negative the ΔH_f value the more stable the oxide (1)
PbO is relatively the more stable / CuO is relatively the less stable (1) [2]
- must have the first mark to get second

(e) (i) Any TWO from
variable oxidation states
partially filled 3d energy levels
ability to adsorb 'molecules'
ability to form complexes with reacting molecules / temporary / co-ordinate bonds

One mark for each correct response [2]

(ii) e.g. to allow lower pressures / temperatures
use recyclable catalysts - needs qualifying [1]
longer lasting / less toxic catalysts

Total [15]

SECTION B

4. (a) $CO \rightarrow C$ +2 $CO_2 \rightarrow$ +4 (1)

Increase of (positive) oxidation number = oxidation / reducing agents themselves are always oxidised are always oxidised (1)

OR

$I_2O_5 \rightarrow I$ +5 $I_2 \rightarrow I_2$ 0 (1)

Oxidation number of iodine reduced, reduction occurring, CO reducing agent (1) [2]

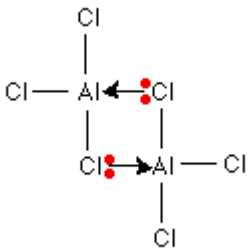
(b) +2 state becomes mores stable down the group and +4 becomes less stable. [1]

(c) (i) Add (a little) sodium hydroxide solution (1) to each solution.
A white precipitate (1) of aluminium / lead(II) hydroxide (1) is seen.
When more sodium hydroxide solution is added these precipitates (dissolve giving a colourless solution). (1) [4]

QWC Legibility of text: accuracy of spelling, punctuation and grammar; clarity of meaning. [1]

(ii) Yellow precipitate (1) $Pb^{2+} + 2\ I^- \rightarrow PbI_2$ [2]

(d) (i) The bonding of **aluminium** in the monomer has not completed the octet / suitable diagram / 6 electrons in its outer shell (1)
When the dimer is formed this octet of bonded electrons is formed (1)



(1) [3]

(ii) (As a catalyst) in the chlorination of benzene / making ionic liquids [1]

(iii) I The number of (gaseous) species is increasing, leading to less order [1]

II For the reaction to be just spontaneous $\Delta G = 0$ (1)

substituting $0 = 60\,000 - 88\ T$

$T = 60\,000 / 88 = 682$ K / 409°C (1) [2]

(e) $K_c = \dfrac{[[Al(H_2O)_5(OH)]^{2+}(aq)][[H^+](aq)]}{[[Al(H_2O)_6]^{3+}(aq)]}$

$\therefore \quad 1.26 \times 10^{-5} = [H^+]^2 / 0.10$

$\therefore \quad [H^+]^2 = 1.26 \times 10^{-6}$ [1]

$\therefore \quad [H^+] = \sqrt{1.26 \times 10^{-6}} = 1.12 \times 10^{-3} \ / \ 0.00112$ (1)

- error carried forward

$pH = - \log_{10} [H^+] = -\log_{10} 1.12 \times 10^{-3} = 2.95$ (1) [3]

Total [20]

5. (a) (i) $K_p = \frac{pSO_3(g) \times pNO(g)}{pSO_2(g) \times pNO_2(g)}$ (1) there are no units (1) [2]

(ii) The line for SO_3 / NO at equilibrium should be above the SO_2 / NO_2 line (1)
as K_p has a value of 2.5, the partial pressures of SO_3 and NO at equilibrium will be greater than the partial pressures of SO_2 and NO_2. (1)
- accept answer in terms of alternative calculated K_p value

The line for equilibrium should start at 9 hours. (1)
as at equilibrium the concentrations is unchanged as time progresses. (1)
[4]

There may be other acceptable forms of explanation to be discussed at the conference

(iii) If the temperature rises then the position of equilibrium will move to the left, (reducing the quantities of SO_3 and NO). (1)
This will make the value of K_p smaller. (1) [2]

(b) (i) Nitric acid is a strong acid and its pH is low / <2 / 1.0 (1)
As aqueous ammonia is added the pH slowly rises (1) until a pH of ~3 is reached, when it rises rapidly (1)
At a pH of 8-9, it tails off slowly as ammonia is a weak base. (1)
Accept any 3 from 4 . [3]

Selection of a form and style of writing which is appropriate to purpose and to complexity of subject matter [1]

(ii) The equivalence point is reached when 20.0 cm^3 of ammonia solution has been added as this is at the mid point of the more vertical section. (1)

Since both reagents have the same concentration and the volumes used are both 20 cm^3 / the same, the number of moles of each are the same (1)

OR the number of moles of both nitric acid and aqueous ammonia are calculated (0.0020) and shown to be the same (1)

∴ Mole ratio must be 1 : 1 (1) [2]

(iii) I Ammonium nitrate is the salt of a strong acid and weak base / there is a buffering effect in operation. [1]
II ~ 5.5 [1]

(iv) Blue, as bromophenol blue is blue at a pH of 4.7 and above [1]

(c) Number of moles of ammonium nitrate = $\frac{40}{80}$ = 0.50 (1)
- error carried forward
Concentration of ammonium nitrate solution = $\frac{0.5 \times 1000}{200}$ = 2.5 mol dm^{-3} (1)

∴ Temperature drop = 2.5 × 6.2 = 15.5°C (1) [3]

Total [20]

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