Marking Schemes

This document was prepared for markers' reference. It should not be regarded as a set of model answers. Candidates and teachers who were not involved in the marking process are advised to interpret its content with care.

Chemistry
Paper 1

SECTION A

Question No.		Key	Question No.		Key
Part I			**Part II**		
1.	C	(85%)	25.	B	(73%)
2.	D	(91%)	26.	C	(46%)
3.	A	(73%)	27.	D	(30%)
4.	A	(88%)	28.	A	(30%)
5.	C	(79%)	29.	D	(56%)
6.	D	(70%)	30.	D	(59%)
7.	C	(70%)	31.	C	(58%)
8.	B	(78%)	32.	B	(58%)
9.	C	(86%)	33.	A	(50%)
10.	D	(73%)	34.	C	(62%)
11.	B	(90%)	35.	A	(58%)
12.	B	(28%)	36.	C	(12%)
13.	D	(69%)			
14.	A	(80%)			
15.	B	(72%)			
16.	B	(76%)			
17.	A	(57%)			
18.	C	(70%)			
19.	D	(77%)			
20.	A	(70%)			
21.	B	(86%)			
22.	A	(25%)			
23.	B	(79%)			
24.	C	(65%)			

Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

General Marking Instructions

1. In order to maintain a uniform standard in marking, markers should adhere to the marking scheme agreed at the markers' meeting.

2. The marking scheme may not exhaust all possible answers for each question. Markers should exercise their professional discretion and judgment in accepting alternative answers that are not in the marking scheme but are correct and well reasoned.

3. In questions asking for a specified number of answers, if a candidate gives more than the required number, the extra answers should not be marked. For instance, in a question asking candidates to provide two examples, if a candidate gives three answers, only the first two answers should be marked.

4. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.

5. Award zero marks for answers which are contradictory.

6. Chemical equations should be balanced except those in reaction schemes for organic synthesis. For energetics, the chemical equations given should include the correct state symbols of the chemical species involved.

7. In the question paper, questions which assess candidates' communication skills are marked with an asterisk (*). For these questions, the mark for effective communication (1 mark per question) will be awarded if the answer is easily understandable. No effective communication marks will be awarded if an answer contains a lot of irrelevant material and/or wrong chemistry concepts.

SECTION B

Part I

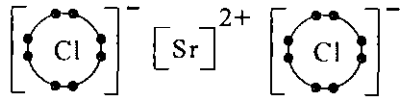
Marks

1. (a) alkaline earth metal — 1

(b) (i) $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$ — 1

(ii) calcium hydrogencarbonate / $Ca(HCO_3)_2$ — 1

(c) $84 \times 0.0056 + 86 \times 0.0986 + 87 \times 0.0702 + 88 \times 0.8256$
$= 87.7$ — 2

(d) (i) 

— 1

(ii) (1) delocalised electrons; strontium ions — 1
(2) giant ionic — 1

(iii) • Solid strontium can conduct electricity because there are delocalised electrons in solid strontium. — 1
• Solid strontium chloride cannot conduct electricity because the ions in solid strontium chloride are fixed and there are no delocalised electrons in solid strontium chloride. — 1

2. (a) fractional distillation of liquefied air — 1

(b) (i) sulphur dioxide / SO_2 — 1

(ii) $Cr_2O_7^{2-}(aq) + 3SO_2(g) + 2H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$ — 1

(c) $2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g)$ — 1

(d) The experiment should be performed in a fume cupboard as SO_2 / PbS / PbO is toxic. — 1

(e) (i) silvery / shiny — 1

(ii) The reaction is a redox reaction because the oxidation number of lead decreases from +2 to 0 / the oxidation number of carbon increases from 0 to +4. — 1

3. (a) **C > A > B** — 1

(b) Gas **Y** can give a 'pop' sound with a burning splint. — 1

(c) (i) Metal **C** moves on water surface / melts to form a silvery ball / burns with a lilac flame / gives a hissing sound. / Colourless gas is given off. — 1

(ii) The reaction is explosive / highly exothermic. — 1

(d) • Put a strip of metal **A** into a test tube containing **B**$NO_3(aq)$. — 1
• Metal **A** dissolves. / A silvery solid is formed. — 1

Marks

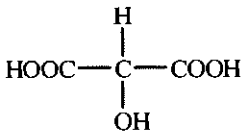
4. (a) (i) No. of moles of NaOH = 0.207 × 0.02462 = 0.00510 — 2
No. of moles of tartronic acid = 0.102 × 0.025 = 0.0026

$$\frac{\text{No. of moles of NaOH}}{\text{No. of moles of tartronic acid}}$$

$$= \frac{0.00510}{0.0026} = 2$$

The basicity of tartronic acid is 2.

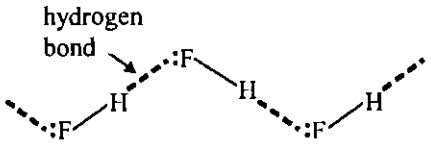
(ii) — 1



(b) • If the tartronic acid is completely ionised in water, the expected $[H^+(aq)]$ = 0.102 × 2 = 0.204 M, then the expected pH = −log (0.204) = 0.69. — 1

• The actual pH (1.87) is higher than 0.69, therefore tartronic acid is not completely ionised in water. — 1

5. (a) — 1



Hydrogen bonding forms between the H atom of a HF molecule and the lone pair of electrons on the F atom of another HF molecule. — 1

F is a highly electronegative element compared to H. / The H–F covalent bond / The HF molecule is very polar. — 1

(b) (i) CH_3F — 1

(ii) **Q** is not a symmetrical molecule, and the polarities of the C–H bonds and C–F bond do not cancel out each other. — 1

6. (a) Energy released = 100.0 × 4.20 × 13.4 = 5 628 J — 2

Enthalpy change of combustion of hexane = −5 628 ÷ (0.120 ÷ 86.0) ÷ 1 000 = −4 033 kJ mol^{-1}

(b) (i) $2C_6H_{14}(l) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(l)$ — 1

(ii) $2 \times \Delta H_c^\circ[C_6H_{14}(l)] = 12 \times (-393.5) + 14 \times (-285.9) - 2 \times (-167.2)$ — 2

$\Delta H_c^\circ[C_6H_{14}(l)] = -4\,195$ kJ mol^{-1}

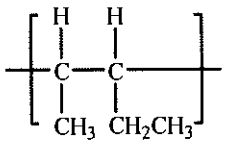
(c) The experiment was not performed under standard conditions. — 1

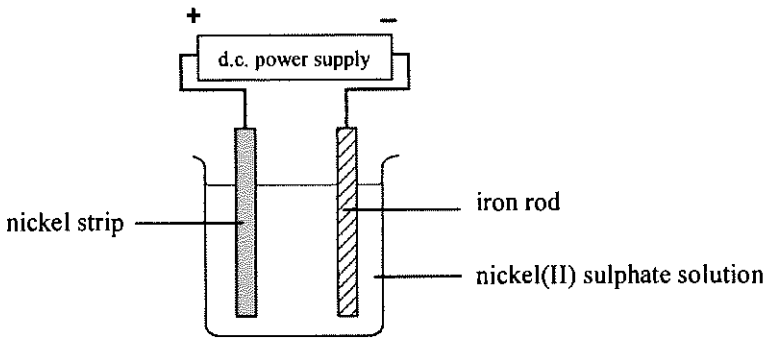
Marks

7. (a) dimethylpropane 1

(b) **Y** gives a more sooty flame than **X** does on burning. / **Y** is more likely to undergo incomplete combustion than **X** is. 1

(c) • Add a small amount of Br_2 (in organic solvent) to **X** and **Y** separately. 1
• **Y** turns Br_2 (in organic solvent) from brown / orange to colourless, but **X** does not. 1
or
• Add a small amount of acidified $KMnO_4(aq)$ to **X** and **Y** separately.
• **Y** turns acidified $KMnO_4(aq)$ from purple to colourless, but **X** does not.

(d)  1

8. (a) 

2

(b) It provides nickel(II) ions for electroplating. /
It provides mobile ions for conducting electricity. 1

(c) $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ 1

(d) • The discharge of $Ni^{2+}(aq)$ ions at the cathode and the formation of $Ni^{2+}(aq)$ ions at the anode occur at the same rate. 1
• There is no change in the concentration of nickel(II) sulphate solution. Thus, there is no observable change in the solution. 1

(e) To increase the corrosion resistance of iron objects. / To improve the appearance of iron objects. 1

9. Chemical knowledge 4
• Add excess solid magnesium carbonate to dilute sulphuric acid, then filter / decant the mixture.
• Heat the solution until it becomes saturated.
• Cool the saturated solution slowly to form crystals.
• Filter the mixture to obtain crystals, wash the crystals with a small amount of cold deionised water, then dry the crystals with filter paper / a desiccator / gentle heating in an oven.

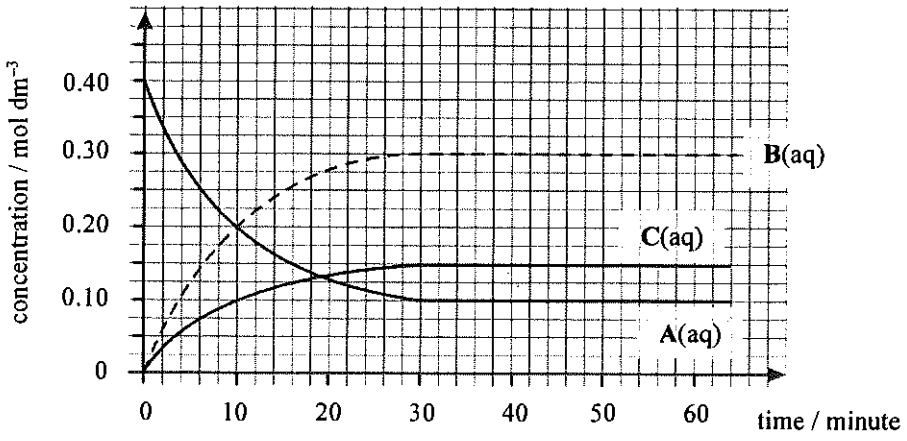
Communication mark 1

Part II

Marks

10. (a) The concentrations of **A**(aq) and **C**(aq) remain constant after the 30th minute. 1

(b) 1



(c) $K_c = \frac{[B(aq)]^2_{eqm}\,[C(aq)]_{eqm}}{[A(aq)]^2_{eqm}}$ 2

$= (0.30)^2\,(0.15) / (0.10)^2$

$= 1.35$ mol dm^{-3}

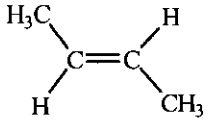
(d) • The equilibrium concentration of **A**(aq) at temperature T_2 is higher than that at temperature T_1, which means the equilibrium position has shifted to the left. 1

• As the forward reaction is endothermic, a decrease in temperature favours the backward reaction. Therefore, T_1 is the higher temperature. 1

Marks

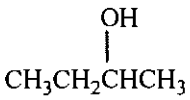
11. (a) (i) *cis*-but-2-ene 1

(ii) 1

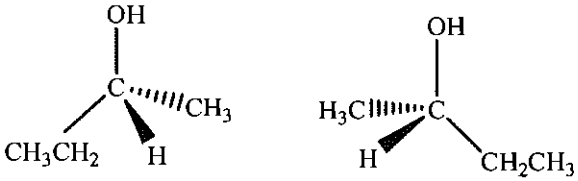


(b) (i) Al_2O_3, heat / conc. H_2SO_4, heat / conc. H_3PO_4, heat 1

(ii) 1

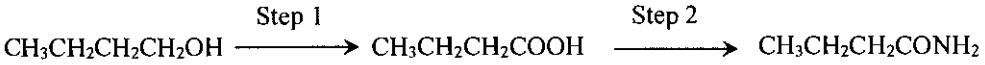


(iii) 2



(iv) The two enantiomers can rotate the plane of plane-polarised light by the same magnitude but in opposite directions. 1

12. 3



Step 1:
$Cr_2O_7^{2-}/H^+$, heat
or
MnO_4^-/H^+, heat

Step 2:
NH_3, heat
or
1. PCl_3 2. NH_3

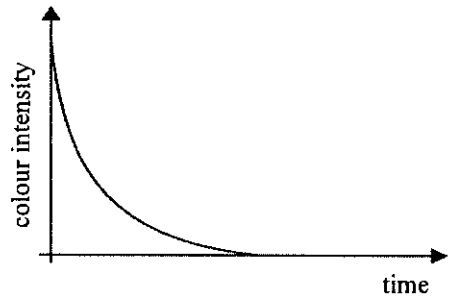
Marks

13. (a)
- SiO_2 has a giant covalent structure, and the Si and O atoms are linked by strong covalent bonds. 1
- Both P_4O_{10} and SO_2 have simple molecular structures, and there are weak van der Waals' forces between their respective molecules. Therefore, the melting point of SiO_2 is the highest. 1
- The molecular size of P_4O_{10} is larger than that of SO_2, and the van der Waals' forces between P_4O_{10} molecules are stronger than those between SO_2 molecules. Therefore, the melting point of P_4O_{10} is higher than that of SO_2. 1

(b) (i) $2Fe^{2+}(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(l)$ 1

(ii)
- Iron exhibits variable oxidation states. The oxidation state of iron changes from +2 in $Fe^{2+}(aq)$ ions to +3 in $Fe^{3+}(aq)$ ions in the reaction. 1
- Iron forms coloured ions in aqueous solutions. $Fe^{2+}(aq)$ ions exhibit pale green / $Fe^{3+}(aq)$ ions exhibit yellow. 1

14. Chemical knowledge 5
- Measure the colour intensity of the reaction mixture at regular time intervals.
- $Br_2(aq)$ is brown while the other reactants and products are colourless. As $Br_2(aq)$ is gradually consumed during the reaction, the colour intensity of $Br_2(aq)$ gradually decreases.
- Labelled graph:



- As the reaction proceeds, the concentration of $Br_2(aq)$ gradually decreases, so the rate of reaction gradually decreases.
- Therefore, the slope of the curve gradually decreases.

Communication mark 1

Paper 2

Marks

1. (a) (i) (1) It solves the problems of inadequate supply of vitamin C from natural sources. 1

(2) Cl_2 is toxic. / NaOH is corrosive. / Conc. H_2SO_4 is corrosive. / Too many wastes will be produced or loss of materials will result as many steps are involved. 1

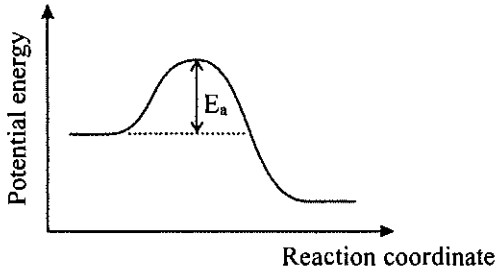
(ii) (1) natural gas / crude oil / municipal waste / biomass / landfill site 1

(2) $CH_4 + H_2O \rightarrow CO + 3H_2$ 1

(iii) Any TWO of the following : 1
chlorine / Cl_2, hydrogen / H_2, sodium hydroxide / NaOH, sodium hypochlorite / NaOCl

(b) (i) 'Activation energy' refers to the minimum energy possessed by the colliding reactant particles in order that a chemical reaction can occur. 1

(ii) 2



(iii) 112 kJ mol^{-1} 1

(iv) 400 – 500 °C and 200 atm 1

- Increasing temperature can increase the reaction rate. However, the forward reaction is exothermic, the higher temperature can shift the equilibrium position to the left and thus decrease the yield of ammonia. 1
- Increasing pressure can shift the equilibrium position to the right and thus increase the yield of ammonia. However, it needs high cost to build up the plant and keep the maintenance and safety under high pressure condition. 1

(v) The statement is incorrect. A catalyst does not shift the equilibrium position and does not affect the yield of ammonia. 1

(c) (i) (1) by making the catalyst into finely divided / powdered form / porous structure 1

(2) To reduce production cost. / To reuse **Y** as the reactant in Step (1). 1

(3) Direct reaction between hydrogen gas and oxygen gas will form water rather than hydrogen peroxide. 1

(ii) (1) Rate = $k[H_2O_2][I^-]^x[H^+]^y$ 2

$$\frac{\text{initial rate 1}}{\text{initial rate 3}} = \frac{2.8 \times 10^{-6}}{2.8 \times 10^{-5}} = \frac{k(0.0010)(0.10)^x(0.10)^y}{k(0.0020)(0.50)^x(0.10)^y}$$

$x = 1$

The order of reaction with respect to $I^-(aq)$ is 1.

$$\frac{\text{initial rate 1}}{\text{initial rate 2}} = \frac{2.8 \times 10^{-6}}{5.6 \times 10^{-6}} = \frac{k(0.0010)(0.10)^x(0.10)^y}{k(0.0020)(0.10)^x(0.0010)^y}$$

$y = 0$

The order of reaction with respect to $H^+(aq)$ is 0.

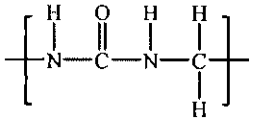
(2) $2.8 \times 10^{-6} = k \times (0.0010)^1 \times (0.10)^1 \times (0.10)^0$ 2

$k = 0.028$ mol^{-1} dm^3 s^{-1}

Marks

2. (a) (i) Any TWO of the following: 2
- In Method (II), H_2O produced is not harmful to the environment. In Method (I), N_2O produced is harmful to the environment.
- In Method (II), no corrosive substance is used. In Method (I), corrosive conc. HNO_3 is used.
- In Method (II), a catalyst is used to increase the reaction rate. In Method (I), no catalyst is used.

(ii) Any TWO of the following: 2
- The molecule contains a long carbon chain that gives the molecule a long rod-like shape.
- The molecule contains benzene rings that can add rigidity to the molecule.
- The molecule contains a C=N group that makes the molecule polar.

(iii)  1

(b) (i) cubic close-packed / face-centred cubic 1

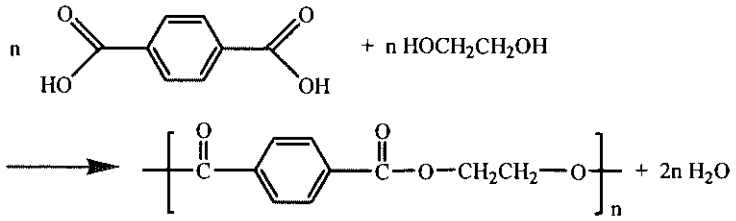
(ii) Number of Ag atoms in the unit cell = $12 \times \frac{1}{4} + 1$ 2
$= 4$

(iii) (1) • The sizes of Cu atoms and Ag atoms are different. The addition of Cu atoms distorts the original regular arrangement of the Ag atoms in Ag metal. 1
• This weakens the strength of metallic bond in the alloy. 1

(2) Sterling silver is harder / more lustrous than pure silver. 1

(iv) • The diameter of the spherical cluster = $0.288 \times 80 = 23.04$ nm 1
• The diameter of the spherical cluster is in the range of 1–100 nm, which is the typical size of a nanoparticle. Thus, this spherical cluster is a nanoparticle. 1

(c) (i) A condensation polymer is a polymer that involves the elimination of small molecules when formed from its monomers. 1

(ii) 1


(iii) PET is a thermoplastic because there are no cross-linkages / covalent bonds formed between polymer chains. 1

(iv) • Cellulose chains consist of many hydroxyl (–OH) groups that can form stronger hydrogen bonds with water molecules. Thus, water does not evaporate easily from the wet cotton towel. 1
• PET chains consist of ester groups, so there are weaker van der Waals' forces between PET and water molecules. Thus, water evaporates more easily from the wet 'cooling towel'. 1

(v) extrusion moulding 1

(vi) It is difficult to remove additives from the 'cooling towel'. 1

Marks

3. (a) (i) • Flame tests are carried out. 1
• $Ca(NO_3)_2(s)$ gives a brick red flame while $Mg(NO_3)_2(s)$ does not give a characteristic flame colour. 1

(ii) Sodium hydroxide solid would absorb water vapour and carbon dioxide gas from air. 1

(iii) $NaHCO_3(aq)$ / $Na_2CO_3(aq)$ / $NaOH(aq)$ is added to the mixture in a separating funnel. After shaking, the upper organic layer is collected. 2

(b) (i) volumetric flask / pipette 1

(ii) (1) from dark blue to colourless 1

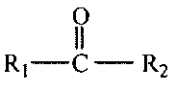
(2) Actual concentration of NaOCl in the bleach 3
$= 0.0512 \times 21.02 \div 1000 \div 2 \times (250.0 / 25.00) \div (25.00 / 1000) \times 74.5$
$= 16.0 \text{ g dm}^{-3}$

(3) The range of the concentration of NaOCl in the bleach that can fulfill the quality control standards is between 14.7 and 16.3 g dm^{-3}. As the actual concentration of NaOCl in the bleach lies within the range, it fulfills the quality control standards. 1

(iii) To reduce errors in the titration results. 1

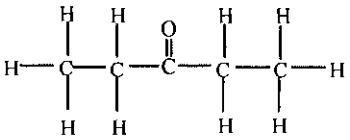
(c) (i) (1) The molecular ion peak is at m/z = 86. The relative molecular mass of **A** is 86. 1
The molecular formula of **A** is $C_5H_{10}O$.

(2) • The peak at m/z = 43 corresponds to CH_3CO^+ and the peak at m/z = 71 corresponds to $CH_3CH_2CH_2CO^+$. 1
• The structural formula of **A** is $CH_3COCH_2CH_2CH_3$. 1

(ii)  1

(R_1 and R_2 : linear alkyl groups; R_1 and R_2 may be the same.)

e.g.



(iii) Correct chemical reagent 1
Correct observations with comparison between the tests on **B** and **C** 1

Possible chemical tests and the corresponding observations:

	$Cr_2O_7^{2-}(aq) / H^+(aq)$	**B** – no observable change; **C** – from orange to green
Or,	$MnO_4^-(aq) / H^+(aq)$	**B** – no observable change; **C** – from purple to colourless
Or,	Tollens' reagent	**B** – no observable change; **C** – silver mirror is formed

(iv) • The IR spectrum of **C** shows a strong absorption peak in the region from 1680 cm^{-1} to 1800 cm^{-1} corresponding to C=O group of aldehyde, while the IR spectrum of **D** does not show this peak. 1
• The IR spectrum of **D** shows a strong absorption peak in the region from 3230 cm^{-1} to 3670 cm^{-1} corresponding to O–H group of alcohol, while the IR spectrum of **C** does not show this peak. 1