Marking Scheme

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Chemistry
Paper 1

SECTION A

Question No. Part I	Key	Question No. Part II	Key
1.	C (70%)	25.	D (79%)
2.	C (92%)	26.	C (72%)
3.	D (64%)	27.	D (61%)
4.	B (62%)	28.	A (79%)
5.	A (71%)	29.	B (56%)
6.	B (51%)	30.	D (65%)
7.	A (66%)	31.	B (70%)
8.	C (41%)	32.	A (41%)
9.	A (64%)	33.	B (81%)
10.	C (75%)	34.	C (56%)
11.	A (62%)	35.	A (31%)
12.	D (80%)	36.	C (62%)
13.	D (74%)		
14.	B (81%)		
15.	B (46%)		
16.	C (65%)		
17.	A (59%)		
18.	A (58%)		
19.	B (65%)		
20.	D (58%)		
21.	D (72%)		
22.	D (49%)		
23.	B (61%)		
24.	C (54%)		

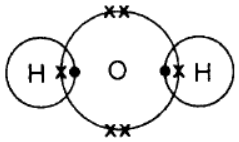
Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

SECTION B

Part I

Marks

1. (a)



1

(b) (i) Water boils at about 100°C, but the salts in sea water are non-volatile. 1
The steam formed condenses on the cold surface of the condenser cool down to give liquid water. 1

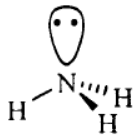
(ii) To prevent bumping / to prevent frothing / splash / overflow due to overheating of water 1

(c) The attraction between water molecules is predominately hydrogen bond. 1
Hydrogen bond is directional. In ice, the water molecules have a tetrahedral arrangement / are packed in an open structure. 1
In liquid water, the water molecules have relative motion and this leads to the collapse of the open structure. The molecules become more closely packed. So liquid water has higher density than ice. 1

2. (a)

1

(Accept other correct representations of the trigonal planar structure.)



1

(Showing the lone pair is NOT a must.)

(b) BF_3 is a non-polar molecule. The three polar B–F bonds are symmetrically arranged on the same plane. 1
NH_3 is a polar molecule. The central atom has a lone pair in its outermost shell and thus the three polar N–H bonds are not on the same plane. 1

(c) In BF_3, there are three bonding electron pairs / there is a vacant site in the outermost shell of the B atom. 1
By accepting the lone pair of electrons from the N atom of NH_3 / forming dative bond with N, the B atom attains the stable electronic configuration of neon (a noble gas). 1

Marks

3. (a) Atom ratio $\frac{C}{\frac{2.64}{44}} : \frac{H}{2\times\frac{1.08}{18}} : \frac{O}{\frac{0.48}{16}}$ 3

$= 2 : 4 : 1$

Empirical formula is C_2H_4O

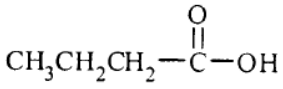
Molecular formula is $(C_2H_4O)_n$

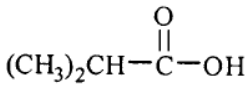
$n\times(12\times2 + 1\times4 + 16\times1) = 88.0$

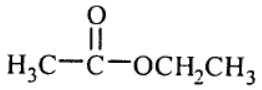
$n = 2$

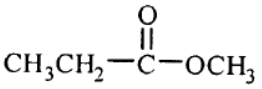
Molecular formula of **W** is $C_4H_8O_2$

(b) Any two of the following structures. 1 mark for each structure. 2









4. (a) Ethanedioic acid 1

(b) $H_2C_2O_4(aq) \rightleftharpoons C_2O_4^{2-}(aq) + 2H^+(aq)$ / $H_2C_2O_4(aq) \rightleftharpoons HC_2O_4^-(aq) + H^+(aq)$ 2

$H_2C_2O_4$ is a weak acid. It undergoes incomplete ionisation in water. As pH = $-\log_{10}[H^+(aq)]$, its pH is thus greater than 1.

(c) NaOH(s) is deliquescent / absorbs water from the atmosphere. 1

Or, NaOH(s) reacts with $CO_2(g)$ in the atmosphere.

So the mass of NaOH(s) cannot be accurately determined by weighing.

(d) (i) From colourless to pink 1

(ii) concentration of NaOH(aq) 2

$= \frac{0.05\times25\times2}{17.20}$

$= 0.145$ mol dm^{-3}

(e) (i) Rinsing the conical flask with $H_2C_2O_4(aq)$: Some $H^+(aq)$ ions remain in the flask, and more alkali (as revealed from the burette reading) than actually required is used to reach the titration end point. 1

(ii) NaOH(aq) clinging onto the stem of funnel may fall into the burette. The volume of alkali used (as revealed from the burette reading) is smaller than what is expected. 1

Marks

5. (a) (i) (26.6 – 19.8) = 6.8°C 1

(ii) Heat absorbed $= mc\Delta T$ 3
$= 21.8 \times 4.3 \times 6.8$
$= 637.4$ J

No. of moles of $NH_4NO_3(s)$ used = 2.0 80
= 0.025

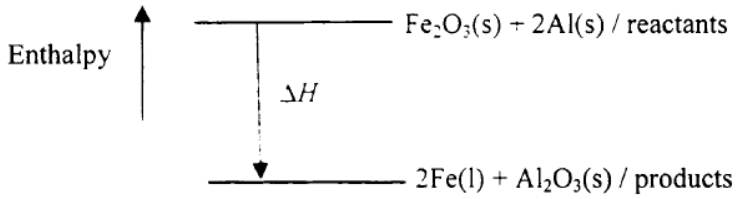
$$\Delta H = +\frac{637.4}{0.025}$$
$= +25.5$ kJ mol^{-1}

(b) Place $NH_4NO_3(s)$ in a desiccator sealed container containing drying agent (anhydrous $CaCl_2(s)$, $CaO(s)$, $MgSO_4(s)$, etc.) silica gel. 1

6. • Cracking of naphtha gives a mixture of hydrocarbons which include propene. 1
• Fractional distillation of the gaseous products can separate propene from other hydrocarbons. 1
• Polymerisation of propene at elevated temperatures / > 45℃ / high pressure / > 5 atm / in the presence of a suitable catalyst / Ziegler-Natta catalyst gives polypropene. 1
• Communication mark 1

7. (a) (i) $Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$ 1

(ii)



1

(b) Copper is less reactive than iron copper has a lower affinity for oxygen than iron. / Copper is a weaker reducing agent than iron. Copper is lower than iron in the chemical reactivity series. So Cu(s) cannot reduce $Fe_2O_3(s)$. 1

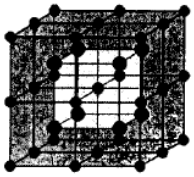
(c) (i) Aluminium is more expensive than iron. 1

(ii) coke / carbon / charcoal / carbon monoxide / CO 1

Marks

8. (a) $2Cs + Cl_2 \rightarrow 2CsCl$ 1

(b) (i) 1



● Chloride ion

• Caesium ion

(ii) In CsCl , ions are strongly held by ionic bond. 1
Relative movement of the ions can bring ions of the same charge close to each other, and will result in repulsion. So CsCl(s) is brittle. 1

(c) Cs(s) is more reactive than Na(s). The reactivity of Group 1 metals increases down the group. / The electron in the outermost shell of Cs is weakly bounded by the nucleus as compared with that of Na. 1

9. (a) Brown colour is observed. 1
Due to the high concentration of KI in the solution, I^- ions are preferentially discharged to give I_2 which dissolves in KI(aq) to give brown I_3^- ions. 1

(b) (i) H^+ ions is discharged and reduced to H_2 at electrode **B**. 1
The amount of OH^- ions increases at electrode **B** as H^+ is being consumed. So universal indicator turns blue under alkaline conditions. 1

(ii) Accept both 'yes' and 'no' answers. 1
'No': **B** is the negative electrode. Copper will not lose electrons to give Cu^{2+} at the negative electrode / Copper cannot undergo reduction at the negative electrode.
'Yes': Copper and carbon have different electrical conductivity. Therefore the solution near electrode **B** turns blue more quickly. / The current in the external circuit changes.

10. (a)

1

(b) electrode **D**: $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$ 1
electrode **E**: $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ 1

(c) (i) Accept both 'agree' and 'disagree' answers. 1
Agree: The hydrogen gas can be obtained from renewable source (with one proper example)
Disagree: The hydrogen gas used is produced from fossil fuel such as steam reforming of natural gas. / Electrical energy is consumed in the production of hydrgoen from water.

(ii) Agree: Only water is produced from the hydrogen-oxygen fuel cells. Or: No CO_2 / SO_2 / NO_x / CO / unburnt hydrocarbon in the exhaust. 1

Part II

Marks

11. (a) The airbag has to be inflated instantly when a car crash occurs. Fine powder can greatly increase the reaction rate by providing a large surface area for a reaction involving solid reactants. 1

(b) No. of mole of N_2 produced from the decomposition of NaN_3 (reaction 1) 3

$$= \frac{100}{65} \times \frac{3}{2} = 2.31$$

No. of mole of N_2 produced from the reaction of Na with KNO_3 (reaction 2):

No. of mole of Na produced = $\frac{100}{65} = 1.54$

(No. of mole of KNO_3 = $\frac{200}{101.1} = 1.98$

Since 5 mol of Na react with 1 mol of KNO_3, KNO_3 is in excess.)

No. of mole of N_2 produced from reaction 2 = $\frac{100}{65} \times \frac{1}{10} = 0.154$

Volume of gas produced = $(2.31 + 0.154) \times 24 = 59.1\ dm^3$

(c) KNO_3 is added to react with sodium which is highly reactive / corrosive / flammable / strongly reducing. 1

(d) (i) $\frac{0.01 - 0.005}{10}$ 1

$= 0.0005\ mol\ dm^{-3}\ s^{-1}$ ($5.0 \times 10^{-4} mol\ dm^{-3}\ s^{-1}$)

(ii) Determine the slope of the tangent of curve at t = 10 s. 1

Marks

12. (a) Reaction quotient = $\frac{(0.04)}{(0.05)(0.02)}$ mol^{-1} dm^3

$= 40$ mol^{-1} dm^3 1

As reaction quotient > K_c, so backward reaction rate is greater than the forward reaction rate. 1

(b) At equilibrium, the concentrations are: 2

$[PCl_5(g)] = (0.04 - y)$ mol dm^{-3}

$[PCl_3(g)] = (0.05 + y)$ mol dm^{-3}

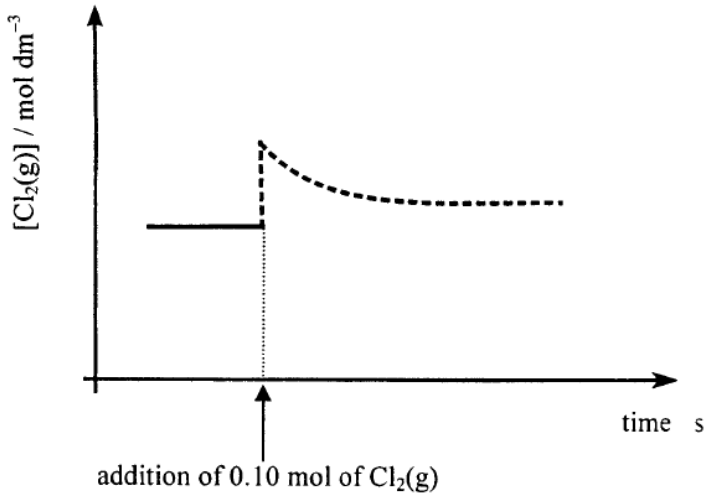
$[Cl_2(g)] = (0.02 + y)$ mol dm^{-3}

$\frac{(0.04 - y)}{(0.05 + y)(0.02 + y)} = 25$

$y = 0.0052$

At equilibrium, $[Cl_2(g)] = (0.02 + 0.0052)$ mol dm^{-3} $= 0.0252$ mol dm^{-3}

(c)



1

13. • Nitrogen < Lithium < Beryllium < Carbon (graphite) 1

• N_2 has the lowest melting point as it has a simple molecular structure, only weak van der Waals' forces / intermolecular forces need to be overcome in melting. 1

• Both Li and Be have metallic structure, metallic bond in Li is weaker than that in Be. So Li < Be in melting points. 1

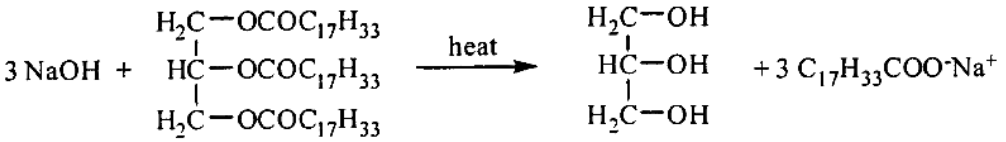
• C has the highest melting point as it has a giant covalent structure, large amount of energy is needed to break millions of strong covalent bonds between atoms in melting. 1

• Communication mark 1

Marks

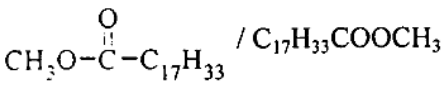
14. **(a) H_2, Ni/ Pd/ Pt** 1

(b) (i)



1

(ii)



/ $C_{17}H_{33}COOCH_3$ 1

(c) **G** has a smaller relative molecular mass than **F**, so **G** can be vaporised more easily than **F.** / **G** has a smaller relative molecular mass than **F**, so **G** has a lower boiling point than **F.** / **G** has a smaller relative molecular mass than **F**, and so the molecular size of **G** is smaller than that of **F**. The intermolecular attraction / van der Waals' forces between **G** are weaker than that between **F, G** can be vaporised more easily than **F**. 1

G burns more completely than **F**. 1

15. (a) Correct chemical reagent 1

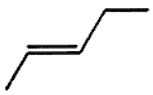
Correct observations with comparison between the tests on **X** and **Y** 1

Possible chemical tests and the corresponding observations:

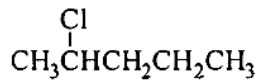
$Cr_2O_7^{2-}$ / H^+	Observations: **X** – no change; **Y** – from orange to green
MnO_4^- / H^+	Observations: **X** – no change; **Y** – from purple to colourless
MnO_4^- / OH^-	Observations: **X** – no change; **Y** – brown precipitate formed
2,4-DNP	Observations: **X** – formation of orange precipitate.; **Y** – no change
CH_3COOH / H^+ / heat	Observations: **X** – no change; **Y** – fruity smell substance formed

(2,4-DNP = 2,4-dinitrophenylhydrazine)

(b) $LiAlH_4$ / $NaBH_4$ 1

(c)  and  1

Geometrical isomerism / *cis-trans*-isomerism 1

(d)  / $CH_3CHClCH_2CH_2CH_3$ 1

Paper 2

Marks

1. (a) (i) (1) x --- molecular kinetic energy 1
y --- fraction / percentage of molecules 1

(2) An increase in temperature from T_1 to T_2 will increase the average kinetic energy of the molecules. 1
This will increase the collision frequency and result in greater effective collisions among molecules. 1
There is a larger portion of molecules will have kinetic energy greater than E_a. 1

(ii) $\log k = \text{constant} - \frac{E_a}{2.3RT}$ 3

Slope of curve $= -\frac{E_a}{2.3R}$

$= -1.73 \times 10^3$

$E_a = 1.73 \times 10^3 \times (8.31 \text{ J K}^{-1} \text{ mol}^{-1}) \times 2.3$

$= 33.1 \text{ kJ mol}^{-1}$

(b) (i) A catalyst provides an alternative pathway with lower activation energy. 1

(ii) Concentrated H_2SO_4
Dilute H_2SO_4 contains a lot of H_2O. Water can shift the equilibrium position to the left / cause hydrolysis of eugenol benzoate, and thus lowers the yield of the product. 1
Or: conc. H_2SO_4 is a dehydrating agent / removes water from the product side of the reaction, and will shift the equilibrium position to the right.

(iii) Homogeneous catalyst --- H_2SO_4 is readily available 1
Heterogeneous catalyst --- can be reused / easily be regenerated / easily be separated 1

(c) (i) Chlorine can be produced by electrolysis of brine / concentrated sodium chloride solution using flowing mercury cell diaphragm cell / membrane cell. 1
Cl^- (aq) ions are discharged at the anode to give Cl_2(g). 1
Diaphragm cell / membrane cell:
H^+(aq) ions are discharged at the cathode. With the removal of Cl^-(aq) ions and H^+(aq) ions, the resultant electrolytic solution contains NaOH(aq) in high concentration. 1
OR Flowing mercury cell:
Sodium amalgam produced at cathode reacts with water forming NaOH(aq).

(ii) Method 2:

Atom economy $= \frac{58}{76} = 76.32\%$ 1

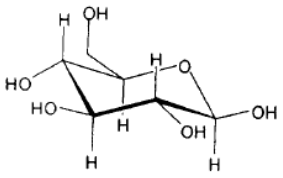
(iii) Method 2 is greener.
Any two of the following: 2
--- It has a higher atom economy.
--- It produces less waste (less side products) and less treatment is required.
--- Less hazardous chemicals are used (method 1 uses more toxic Cl_2).

(iv) The calculation of atom economy is based on a 100% completed reaction. Most reactions do not go to completion and the yield is related to the extent of reaction. 1
Thus a reaction with high atom economy does not necessarily have a high yield. 1

Marks

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

(2) 1



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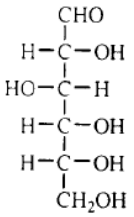

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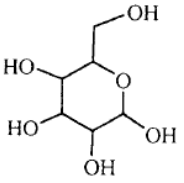
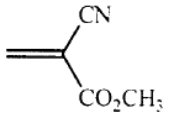


(Accept other correct representations of the structure of glucose.)

(ii) Molecules of cellulose may contain various number of glucose molecules joined together. 1

(iii) Glucose is very soluble in water while cellulose is insoluble in water. 1
A glucose molecule has 5 –OH groups which can attract water molecules strongly via hydrogen bonds. 1
The –OH groups of a cellulose molecule form hydrogen bonds with other cellulose molecules, therefore they are less available to form hydrogen bonds with water molecules. 1

(b) (i) The solid becomes soften upon heating. 1
The heat energy absorbed helps the polymeric molecules to overcome the intermolecular attraction and the molecules can have relative translational motion. 1
At very high temperature, the glue chars / burns. 1

(ii) (1) 

1

(2) Both propanone and poly(methyl 2-cyanoacrylate) are polar organic molecules. 1
The intermolecular attraction in the two compounds is of the same type (polar attraction). Thus, propanone can dissolve poly(methyl 2-cyanoacrylate). 1

(iii) Methyl cellulose is more readily degraded in the environment.
Methyl cellulose is produced from cellulose, a natural material, which is more biodegradable / can be degraded by actions of bacteria or enzymes. 1
Poly(methyl 2-cyanoacrylate) contains long carbon chains which are not readily decomposed. 1

(c) (i) In both nematic phase and smectic phase, the molecules are arranged along one direction. 1
In the smectic phase, the molecules are positionally aligned with each other along a straight line. In the nematic phase, they are not aligned. 1

(ii) Molecule **A** exhibits the cholesteric phase as it is chiral and only chiral compounds can exhibit the cholesteric phase. 1

(iii) The compound solidifies at a very low temperature. 1

(iv) Liquid crystals displays need a backlight source, but OLED displays do not. 1
Liquid crystals act as optical filters to filter off the light from the backlight to give dark spots. Only a small fraction of light passes through them and makes up the images. 1

Marks

3. (a) Use separating funnel to remove water (the lower liquid layer) from the mixture. 1
The upper layer remaining in the funnel is hex-1-ene and octane. 1
Carry out fractional distillation on the upper layer. 1
The first distillate collected is hex-1-ene. The second distillate collected is octane. 1

(b) (i) Any one of the following: 1
--- a significant observable change can easily be detected with the complete consumption of the reagent in the conical flask, i.e. availability of suitable indicator
--- the reaction must be significantly complete
--- the rate of reaction must be fast enough to be practical

(ii) SO_2 easily escapes from solution / I_2 is volatile. 1

(iii) from colourless to dark blue 1

(iv) No. of mole of I_2 used = $0.00412 \times 10.50 \times 10^{-3}$ 4
$= 4.33 \times 10^{-5}$
No. of mole of SO_2 = No. of mole of I_2
$= 4.33 \times 10^{-5}$
Mass of SO_2 in the wine sample = $4.33 \times 10^{-5} \times 64.1$
$= 2.77 \times 10^{-3}$ g
$= 2.77$ mg
Concentration of SO_2 in the wine sample = $\frac{2.77}{0.025} = 111$ mg dm^{-3}

(v) This method cannot be used as the intense red colour of red wine may mask the colour of iodine / iodine-starch complex which leads to a difficulty in the end point detection. 1
Or
This method can be used if the colour of red wine can be removed.

(c) (i) $\frac{2.3}{2.3+1.9+2.9} = \frac{2.3}{7.1} = 0.32$ 1

(ii) β -carotene because
lycopene has a smaller R_f value / lycopene moves slower / lycopene takes a longer time to reach the bottom of the column. 1

(iii) Method: colorimetry / use of colorimeter 1
Measurement: absorbance / colour intensity 1

(iv) Compound **W** is lycopene. 1
The absence of absorption peaks at around 2070 – 2250 cm^{-1} suggesting it does not contain C≡C groups, ruling out the possibility of compound **X**. 1
The absence of absorption peaks at around 2200 – 2280 cm^{-1} suggesting it does not contain C≡N groups, ruling out the possibility of compound **Y**. 1
OR
The presence of absorption peaks at around 1630 cm^{-1} shows the presence of C=C, ruling out the possibility of compound **Y**.
The absence of sharp absorption peaks at around 3350 – 3500 cm^{-1} suggesting it does not contain $-NH_2$ groups, ruling out the possibility of compound **Z**. 1
Compound **W** is a hydrocarbon which contains only C-H, C-C and C=C bonds. This agrees with the feature of the spectrum as there are small peaks at around 1630 cm^{-1}, showing the presence of C=C.