SECTION B

Part I

Marks

1. (a) (i) The mass number of a ^{13}C atom is greater than that of a ^{12}C atom. / 1
The mass number of a ^{12}C atom is 12 while the mass number of a ^{13}C atom is 13. /
A ^{13}C atom has one more neutron than a ^{12}C atom. /
A ^{12}C atom has 6 neutrons while a ^{13}C atom has 7 neutrons.

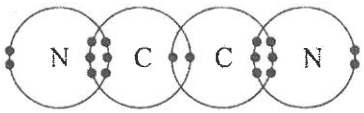
(ii) Let x be the percentage abundance of ^{12}C. 2
$12\,x + 13\,(1 - x) = 12.011$
$x = 0.989 = 98.9\%$

(b) Similarity:
Both diamond and graphite have a giant covalent structure. 1

Difference:
In diamond, each carbon atom forms 4 covalent bonds with other carbon atoms. 1
In graphite, each carbon atom forms 3 covalent bonds with other carbon atoms.

As there are no delocalised electrons in diamond, it is a poor conductor of electricity. 1
As there are delocalised electrons in graphite, it is a good conductor of electricity.

(c)



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2. (a) in the presence of air / oxygen and water 1

(b) phenolphthalein 1

(c) • Iron loses electrons / is oxidised to form iron(II) ions / $Fe^{2+}(aq)$ ions. 1
• $Fe^{2+}(aq)$ ions react with potassium hexacyanoferrate(III) to form a blue colour. 1

(d) **Y** > iron > **X** 1
No blue colour is observed / No rusting occurs in set-up 2, which implies that **Y** loses electrons / is oxidised more readily than iron / **Y** gives sacrificial protection for iron. 1
Blue colour is observed / Rusting occurs in set-up 1, which implies that iron loses electrons / is oxidised more readily than **X**.

Marks

3. (a) voltmeter / multimeter — 1

(b) To complete the circuit / balance the charges in the two half cells / allow the flow of ions between the two half cells. — 1

(c) (i) $AgNO_3(aq)$ / $Ag^+(aq)$ reacts with $KCl(aq)$ / $Cl^-(aq)$ to form water-insoluble $AgCl(s)$, which will block the ion flow in the salt bridge. — 1

(ii) saturated / concentrated potassium nitrate solution / $KNO_3(aq)$ — 1

(d) (i) Mn — 1
Under using the same metal-metal ion in half-cell **A**, the voltage of chemical cell 3 is the greatest positive value / the highest. — 1

(ii) $+1.15-(-0.46) = +1.61$ — 1

(iii) $Ag^+(aq) + e^- \rightarrow Ag(s)$ — 1

4. (a) (i) No. of moles of H = 3.09 / 1.0 = 3.09 — 2
No. of moles of N =14.42 / 14.0 = 1.03
No. of moles of S = 33.06 / 32.1 = 1.03
No. of moles of O = 49.43 / 16.0 = 3.09

Mole ratio of H : N : S : O = 3 : 1 : 1 : 3
The empirical formula of sulphamic acid is H_3NSO_3.

(ii) Let the molecular formula be $(H_3NSO_3)_n$. — 1
$(3 \times 1.0 + 14.0 + 32.1 + 3 \times 16.0) \times n = 97.1$
$n = 1$
The molecular formula of sulphamic acid is H_3NSO_3.

(b) (i) No. of moles of NaOH that reacted with the $H_2SO_4(aq)$ — 1
$= 2 \times 0.202 \times 24.80 / 1000 = 0.010$

(ii) No. of moles of NaOH that reacted with the sulphamic acid — 1
$= 0.150 \times 100.0 / 1000 - 0.010 = 0.005$

(iii) No. of moles of the sulphamic acid that reacted with NaOH(aq) — 1
$= 0.486 / 97.1 = 0.005$

Mole ratio of H_3NSO_3 : NaOH = 0.005 : 0.005 = 1 : 1

The basicity of sulphamic acid is 1. / Sulphamic acid is a monobasic acid.

(c) $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$ — 1

Marks

5. (a) Fractional distillation 1
Different hydrocarbons evaporate and condense as different fractions at different temperatures. 1

(b) (i) cracking 1

(ii) Prevent sucking back of water as sudden cooling may break the hot boiling tube. 1

(iii) The gas mixture contains alkenes which react with $Br_2(aq)$ to give colourless products. 1

(iv) • Kerosene vaporises quickly without being cracked. 1
• The broken unglazed porcelain is not hot enough and so cannot function as a catalyst for cracking of kerosene. 1

6. (a) (i) $NH_3(aq)$ and $FeSO_4(aq)$ 1

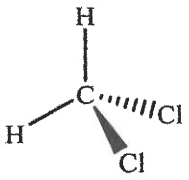
(ii) iron(II) hydroxide 1

(b) (i) $Mg(NO_3)_2(aq)$ and $Na_2CO_3(aq)$ 1

(ii) $Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)$ 1

(c) $H_2SO_4(aq)$ and $Na_2CO_3(aq)$ 1

7. (a) (i) 1



(ii) • C–H bonds are polar because carbon and hydrogen have different electronegativities. 1
• C–Cl bonds are polar because carbon and chlorine have different electronegativities. 1

(iii) Dichloromethane is a polar molecule, because the polarities of C–H bonds and C–Cl bonds do not cancel out each other. 1

(b) • There are weak van der Waals' forces between dichloromethane molecules. 1
• There are strong hydrogen bonds between ethanol molecules. 1

Marks

8. (a) Energy released from the reaction = $1.0 \times (50.0 + 50.0) \times 4.20 \times 6.8 \div 1\,000 = 2.856$ kJ
Enthalpy change of neutralisation = $-2.856 \div (1.0 \times 50 \div 1\,000) = -57.12$ kJ mol^{-1} 2

(b) All acids and alkalis used in experiments 1 to 4 completely dissociate in water. 1

(c) Enthalpy change for the reaction
= $-50.10 - (-57.12)$
= $+7.02$ kJ mol^{-1} 2

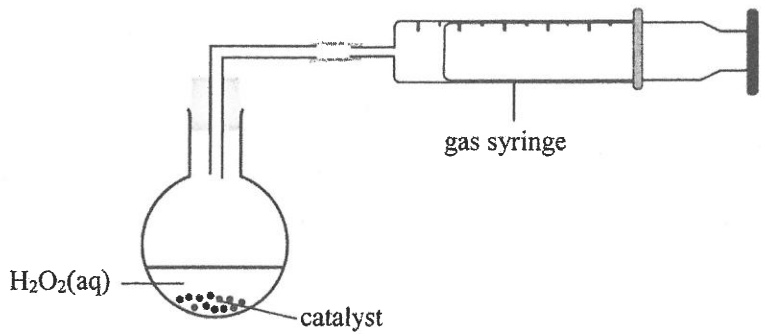
9. Chemical knowledge 4
- Silver can be obtained by heating silver oxide alone / directly.
- Lead can be obtained by heating a mixture of lead(II) oxide and carbon / charcoal / coke.
- Aluminium can be obtained by electrolysis of aluminium oxide in molten state.
- The more reactive a metal is / The higher the position of a metal in the metal reactivity series is, the more difficult the extraction method of the metal is.

Communication mark 1

Part II

Marks

10. (a)

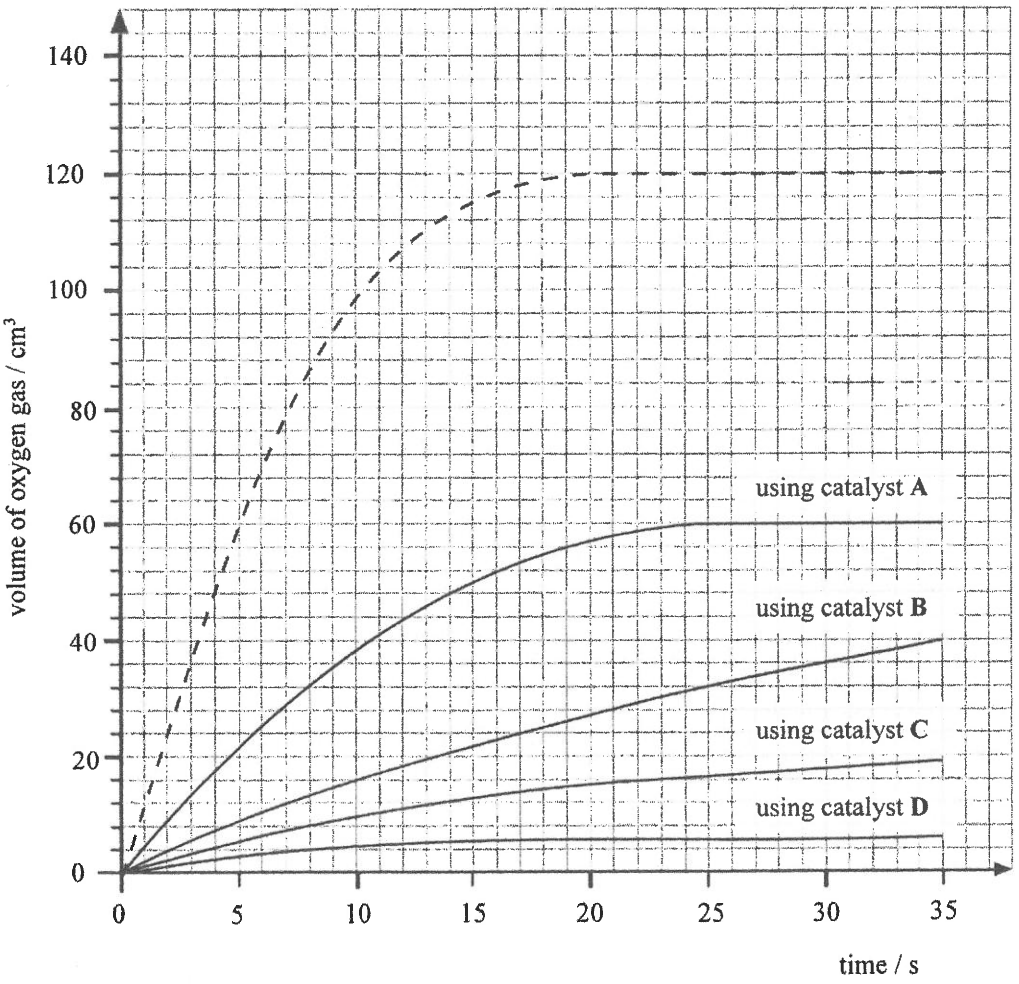


1

(b) **A**, because it takes the shortest time for the reaction to finish / the initial rate of the reaction is the highest. 1

(c) 60 cm^3 1

(d) 2

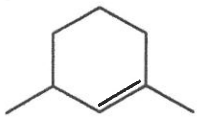


Marks

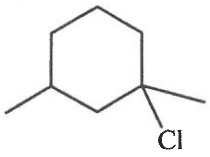
11. (a) 1. $LiAlH_4$, dry ether 2. $H^+(aq)$ 1
OR
$NaBH_4$

(b) dehydration 1

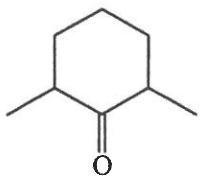
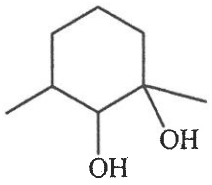
(c) **R**: 1



(d) **S**: 1



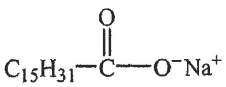
(e)

Q	**R**
	

1
2

12. (a) propane-1,2,3-triol 1

(b) 1



(c) (i) There are no two distinct liquid layers after the mixture has rested for a long time. / One persistent milky layer is formed. 1

(ii) • The ionic head (COO^-) of product **B** dissolves in water / is hydrophilic, while the hydrocarbon tail ($C_{15}H_{31}$) dissolves in oil / is hydrophobic. 1
• By shaking, the oil breaks up into oil droplets. The repulsion between the negative charges on the oil droplets prevents the oil droplets from joining together again. 1

Marks

13. (a) • Al_2O_3 is a basic oxide and reacts with HCl(aq) to form $AlCl_3$ and H_2O. / 1
$Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$

• Al_2O_3 is an acidic oxide and reacts with NaOH(aq) to form $NaAl(OH)_4$ / $NaAlO_2$ and H_2O. / 1
$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2NaAl(OH)_4(aq)$

• Aluminium oxide is both an acidic oxide and a basic oxide. 1

(b) Both S_8 and Cl_2 have a simple molecular structure and there are weak van der Waals' forces between their respective molecules. 1
The molecular size of S_8 is larger than that of Cl_2 and the van der Waals' forces between S_8 molecules are stronger than those between Cl_2 molecules. 1

14. Chemical knowledge 5

Observable change in both cases:
- The equilibrium mixture changes from pink to blue / becomes more intense in blue.

Addition of NaCl(s):
- When the concentration of $Cl^-(aq)$ ions increases, the equilibrium position shifts to the right.
- The equilibrium constant / K_c remains unchanged.

Increase in the temperature:
- As the forward reaction is endothermic, an increase in temperature favours the endothermic side of reaction and the equilibrium position shifts to the right.
- The equilibrium constant / K_c increases.

Communication mark 1

Paper 2

Marks

1. (a) (i) (1) Haber process — 1

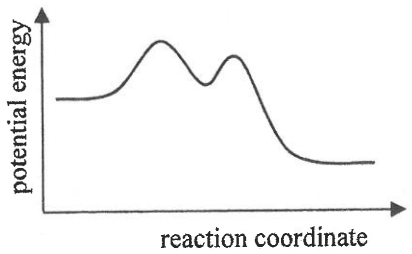
(2) It is a fertiliser. / It can increase the crop yield. — 1

(ii) (1) concentrated sodium chloride solution / brine — 1

(2) No toxic mercury will be produced by membrane electrolytic cells but toxic mercury may leak out from flowing mercury cells. / The operation of membrane electrolytic cells requires less energy than flowing mercury cells. — 1

(iii) Yeast provides enzyme / catalyst. — 1

(b) (i) — 2



(ii) $\frac{4\times60.0}{2\times58.0+5\times32.0}\times100\% = 87.0\%$ — 1

(iii) $CH_3OH + CO \rightarrow CH_3COOH$ — 1

(iv) HI is regenerated at the end of the reaction. — 1

(v) (1) Toxic CH_3OH / CO and corrosive HI are used in Method 2 while these substances are not used in Method 1. — 1

(2) The atom economy is 100% in Method 2 but not in Method 1. / Method 2 has higher atom economy than Method 1. — 1

(c) (i) Use a gas syringe to follow the change in the volume of the gaseous mixture at regular time intervals. / Use a pressure sensor connected to a data logger to follow the change in the pressure of the gaseous mixture at regular time intervals. — 1

(ii) (1) $a = 1$ — 1

(2) $\log \frac{k2}{k1} = \frac{Ea}{2.3R}\left(\frac{1}{T1} - \frac{1}{T2}\right)$ — 2

$\log\left(\frac{k}{4.29\times10^{-4}}\right) = \frac{108500}{2.3\,(8.31)}\left(\frac{1}{318} - \frac{1}{338}\right)$

$k = 4.88\times10^{-3}\ s^{-1}$

(iii) (1) **B** — 1

(2)
- An increase in temperature can increase the average kinetic energy of the molecules. — 1
- There are more molecules having kinetic energy equal to or greater than the activation energy. — 1
- This will increase the effective collision frequency / the number of effective collisions per unit time. — 1

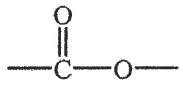
Marks

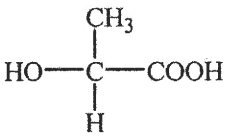
2. (a) (i) • When a rubber band is stretched, the polymer chains move only slightly without breaking the disulphur cross-linkages. 1
• When the stretching force is removed, the polymer chains are still held together by the cross-linkages, and they return to their original position. 1

(ii) (1) $NHCOCH_3$ / acetylamino group 1

(2) There are hydrogen bonds between the polymer chains of chitin. 1

(iii) smectic phase 1

(b) (i) ester group /  1

(ii)  1

(iii) PLA is formed by joining up the monomer molecules repeatedly with the elimination of small molecules. 1

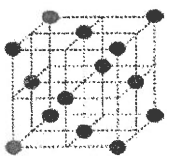
(iv) Corn starch is a renewable resource. 1

(v) PLA is non-toxic / biocompatible. 1

(vi) Not suitable, because PLA is a thermoplastic. 1

(vii) Because ethyl ethanoate molecules and PLA molecules are polar, while hexane molecules are non-polar. / The intermolecular attractions in ethyl ethanoate and PLA are similar while that in hexane is different. 1

(c) (i) 8 1

(ii) (1)  1

(2) A-B-C type packing 1

(iii) The deduction is incorrect. As the temperature increases, the iron metal expands on heating, so the density of iron at 1 450 °C is lower. 1

(iv) (1) Kevlar
• It has a higher tensile strength than iron. 1
• It has a lower density than iron. 1

(2) • There are more hydrogen bonds between the polymer chains of Kevlar than those of nylon-6,6. 1
• Kevlar has many benzene rings which restrict the movement between the polymer chains, but nylon-6,6 does not have. 1

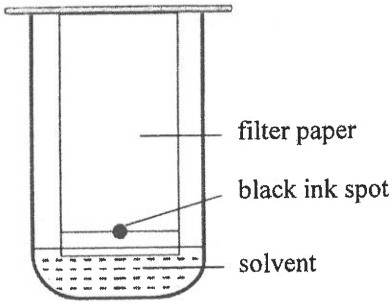
Marks

3. (a) (i)
- Add 2,4-dinitrophenylhydrazine. 1
- Compound **A** forms a yellow / orange / red precipitate while compound **B** does not. 1

OR

- Add $Na_2CO_3(aq)$ / $NaHCO_3(aq)$. / Add deionised water and then add Mg(s).
- Compound **B** gives out a colourless gas while compound **A** does not.

(ii) 2



(iii) Any one of the following: 1
- These solvents are immiscible with water.
- These solvents do not react with the organic compounds.
- These solvents can dissolve more organic compounds than water can.
- These solvents have low boiling points / can evaporate easily.

(b) (i) To ensure that all $PbCO_3(s)$ and $CuCO_3(s)$ have completely reacted with dilute $HNO_3(aq)$. 1

(ii) A deep blue solution is formed. 1

(iii) (1)
- Washing is to remove water soluble impurities and drying is to remove water. 1
- To obtain a more accurate mass of $Pb(OH)_2(s)$. 1

(2) lead(II) hydroxide / $Pb(OH)_2$ 1

(3) Percentage by mass of $PbCO_3$ in the solid sample 2

$$= \frac{1.47}{(207.2+16.0\times2+1.0\times2)} \times (207.2 + 12.0 + 16.0 \times 3) \div 2.03 \times 100\%$$

$$= 80.22\%$$

(c) (i) The infra-red spectrum of the indoor air sample shows a strong absorption peak in the region from 1 680 cm^{-1} to 1 800 cm^{-1} corresponding to the carbonyl group / C=O bond of formaldehyde. 1

(ii) HCO^+ 1

(iii) (1) colorimeter 1

(2) The absorbance is directly proportional to the concentration of formaldehyde. 1

(3) From the graph, the concentration of formaldehyde in solution **S** is 0.25 mg dm^{-3}. 2
Mass of formaldehyde = 0.25 × 0.03 = 0.0075 mg

(4) Concentration of formaldehyde in the indoor air sample 1
= 0.0075 / 0.1 = 0.075 mg m^{-3} < 0.1 mg m^{-3}
Therefore, the quality of the air inside the room is good.

(5) Instrumental analytical methods are sensitive enough to measure very low levels of formaldehyde. 1