SOLUTION TO 5070/22/M/J/19

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SECTION A: Q1

	ANSWER	NOTES
a	H_2S	Number of protons in: each H = 1 S = 16 Total = 18
b	MnO_4^-	In the presence of a reducing agent, MnO_4^- gets decolourised (purple to colourless).
c	NH_4^+	Number of electrons in: each H = 1 N = 7 Total = 11 − 1 = 10 1 electron is subtracted from the total to account for 1+ charge.
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	SECTION A: Q2	
	ANSWER	**NOTES**
a (i)	Any value in the range 0.155 – 0.190 nm	
(ii)	The melting point decreases from B to Ga and increases again from Ga to Tl. It does not seem to follow a general trend (unlike the atomic radius).	
b	The atoms in Boron are held together by an extensive network of strong covalent bonds. A large amount of heat energy is required to overcome many of these bonds, hence high melting point.	
c (i)	Aluminium oxide dissolved in molten cryolite	
(ii)	carbon / graphite	
(iii)	negative electrode: $Al^{3+} + 3e^- \rightarrow Al$ positive electrode: $2O^{2-} \rightarrow O_2 + 4e^-$	
d	Al gets oxidised. Al loses electrons to form Al^{3+}.	Loss of electrons is oxidation. Gain of electrons is reduction.
e	Aluminium has an adherent layer of oxide on its surface which is impermeable to water, hence does not react with water.	Al is apparently unreactive due to its adherent oxide layer.

SECTION A: Q2
(continued from previous page)

	ANSWER	NOTES
f	Excess of Aluminium is added to a solution of warm dilute Hydrochloric acid with stirring. $2Al\ (s) + 6HCl\ (aq) \rightarrow 2AlCl_3\ (aq) + 3H_2\ (g)$ The mixture is filtered to remove the excess Aluminium. The filtrate is partially evaporated till some solid appears and then left to cool for crystals to form (crystallisation). (The crystals are separated from the residual liquid by filtration and washed with a little water.) The crystals can be purified further by recrystallisation using a suitable solvent.	

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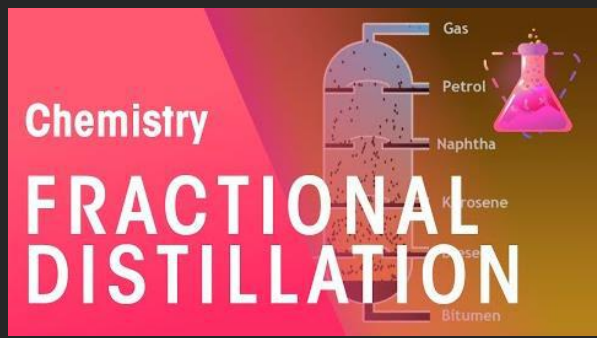
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SECTION A: Q3		
	ANSWER	**NOTES**
a	high melting point / high boiling point / high density / good conductor of electricity / good conductor of heat / malleable / ductile / hard / strong / sonorous	Titanium is a transition metal. Transition metals are typical metal. All physical properties of typical metals apply to transition metals.
b (i)	$TiCl_4$ has a simple covalent molecular structure.	
(ii)	$TiCl_4 (l) + 2H_2O (l) \rightarrow TiO_2 (s) + 4HCl (aq)$	
c	**Mole ratio** 1 mol of $TiCl_4$: 1 mol of Ti	
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SECTION A: Q4

	ANSWER	NOTES
a	Petroleum (crude oil) can be separated into useful fractions by fractional distillation. It is vaporised by heating. The vaporised mixture is led into the fractionating column. The fractions have different boiling points. They start condensing at different levels as they rise up the column. The fractions with higher boiling points condense at the bottom while the ones with lower boiling points come off from the top of the column.	
b	Bitumen is used for resurfacing of roads / waterproofing structures.	
c (i)	The general formula of alkanes is C_nH_{2n+2}, where n = number of carbon atoms. $C_{12}H_{26}$ conforms to this formula for n = 12. $C_{12}H_{12\times2 + 2} = C_{12}H_{26}$	
(ii)	$C_{12}H_{26} \rightarrow C_{12}H_{24} + H_2$ **OR** $C_{12}H_{26} \rightarrow H_2 + 3C_4H_8$	

SECTION A: Q4
(continued from previous page)

	ANSWER	NOTES
d	Hydrogen is a clean fuel (no pollution). The only product formed upon combustion of Hydrogen is water unlike petrol which produces carbon dioxide – a greenhouse gas. Hydrogen does not contribute to air pollution / greenhouse effect / global warming. OR Hydrogen is a renewable energy resource unlike Petrol. Hydrogen can be obtained by the electrolysis of water which is a renewable resource.	

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SECTION A: Q5

	ANSWER	NOTES

a

	C	H	O
mass/100 g	57.1	4.8	38.1
A_r	12	1	16
n	$\dfrac{57.1}{12}$ $= 4.76$	$\dfrac{4.8}{1}$ $= 4.8$	$\dfrac{38.1}{16}$ $= 2.38$
Mole ratio	$\dfrac{4.76}{2.38}$ $= 2$	$\dfrac{4.8}{2.38}$ ≈ 2	$\dfrac{2.38}{2.38}$ $= 1$
Empirical formula	**C_2H_2O**		

b

V (KOH) = 18.5 cm^3 = 0.0185 dm^3

n (KOH) = 0.0185 × 0.250 = 0.004625

mole ratio
1 mole of W : 3 moles of KOH

n (W) = 0.004625 × $\dfrac{1}{3}$ = 0.00154

relative formula mass of U

$= \dfrac{0.194}{0.00154}$

$= 125.97 \approx 126$

NOTES (b):

1 dm^3 = 1000 cm^3

Number of moles
= concentration × volume
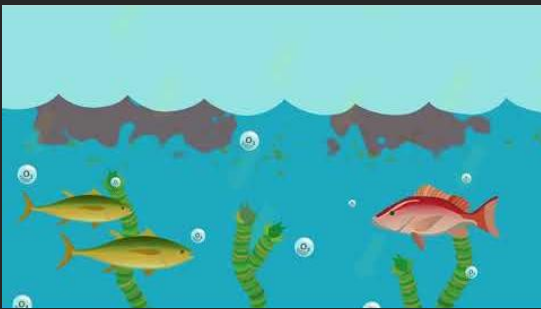
SECTION A: Q5
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	ANSWER	NOTES
c	Empirical formula mass of W $= 12 \times 2 + 1 \times 2 + 16$ $= 42$ Relative formula mass of W $= 126$ $\dfrac{126}{42} = 3$ Molecular formula of W $= (C_2H_2O)_3$ $= \mathbf{C_6H_6O_3}$	

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SECTION A: Q6

	ANSWER	NOTES
a	Desalination is the removal of (dissolved) salts from sea-water.	Desalination is generally carried out by the process of distillation.
b (i)	fertilisers	
(ii)	eutrophication	
c (i)	Insoluble solids can be removed by filtration.	
(ii)	Activated carbon / charcoal	
(iii)	Chlorine	

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SECTION B: Q7

	ANSWER	NOTES
a	Ammonium iodide has decomposed completely when no more of the white solid is left in the tube.	
b	Molar mass of ammonium iodide = 145 g n (ammonium iodide) = $\dfrac{2.90}{145}$ = 0.02 **mole ratio** 1 mol of NH_4I : 1 mol of NH_3 : 1 mol of HI 0.02 mol of NH_4I : 0.02 mol of NH_3 : 0.02 mol of HI Total moles of ammonia and hydrogen iodide gas = 0.02 + 0.02 = 0.04 Total volume of ammonia and hydrogen iodide = 0.04 × 24 = 0.96 dm^3	Molar mass of ammonium carbonate = 14 + 4 × 1 + 127 = 145 g 1 mol of a gas at room temperature and pressure occupies 24 dm^3.
c	**Test:** Acidify with dil. HNO_3 and add aq. Silver nitrate **result:** pale yellow ppt. obtained	Iodide ions react with Silver ions to form a pale-yellow precipitate of Silver iodide.

SECTION B: Q7
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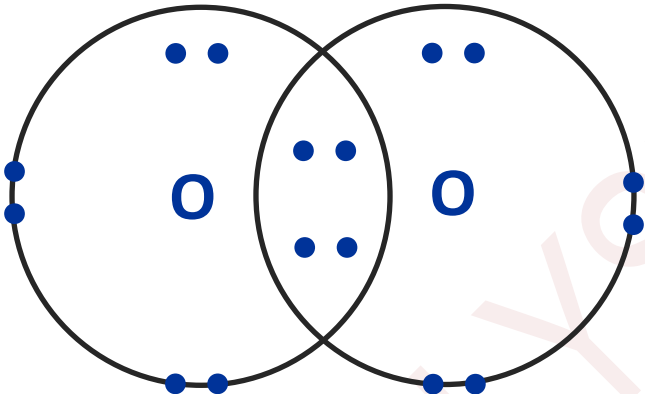|	ANSWER	NOTES
d	$2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$	**Chemical equation:** $2NH_4I\ (aq) + Br_2\ (aq)$ $\rightarrow 2NH_4Br\ (aq) + I_2\ (aq)$ **Ionic equation:** $2\cancel{NH_4}^+\ (aq) + 2I^-(aq) + Br_2\ (aq)$ $\rightarrow 2\cancel{NH_4}^+\ (aq) + 2Br^-(aq) + I_2\ (aq)$ **Net Ionic equation after eliminating the spectator ions:** $2I^-(aq) + Br_2(aq) \rightarrow I_2(aq) + 2Br^-(aq)$
e	In solid ammonium iodide, the ions cannot move as they are held together in a lattice structure by strong ionic bonds. In aqueous solution, the ions can move and are therefore free to conduct electricity.	
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SECTION B: Q8		13
	ANSWER	**NOTES**
a	None of the reactants / products can escape from a closed system, hence equilibrium can be established.	
b	**Prediction:** More of NO and O_2 will be formed or the concentration of NO and O_2 in the equilibrium mixture will increase **Explanation:** Decrease in pressure favours the side with greater number of moles of gas. In this case, the equilibrium shifts to the left, hence more of NO and O_2 are formed.	
c (i)	The forward reaction is exothermic. Decrease in temperature favours the exothermic reaction, hence equilibrium shifts to the right.	
(ii)	Decrease in temperature decreases the average kinetic energy of the reacting particles. The particles move slower and collide less often (collision rate decreases). A lower proportion of particles collide with an energy $\geq$ activation energy. The frequency of successful collisions decreases resulting in slower reaction.	

SECTION B: Q8
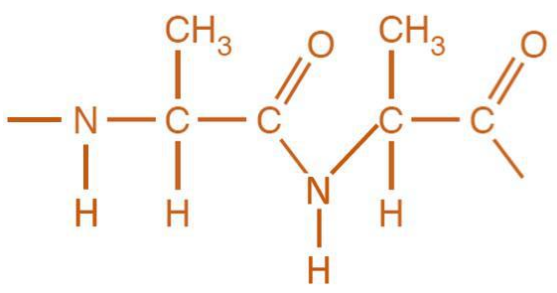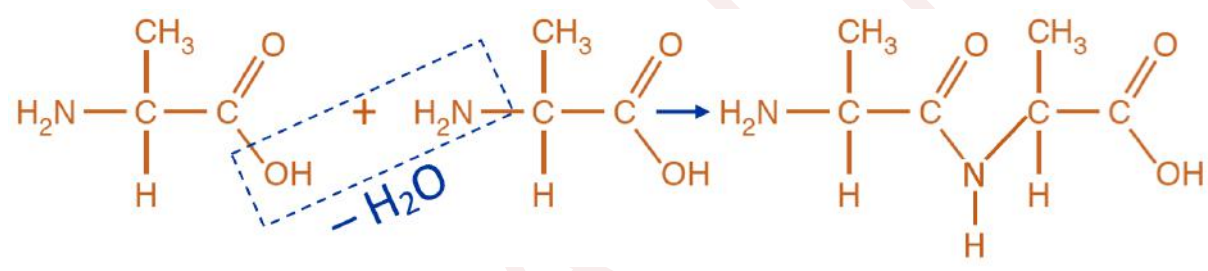### (continued from previous page)

	ANSWER	NOTES
d	↓	
e	$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$	
f	Strong acid completely dissociates / ionises in an aqueous solution. Weak acid partially dissociates /ionises in an aqueous solution.	

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SECTION B: Q9

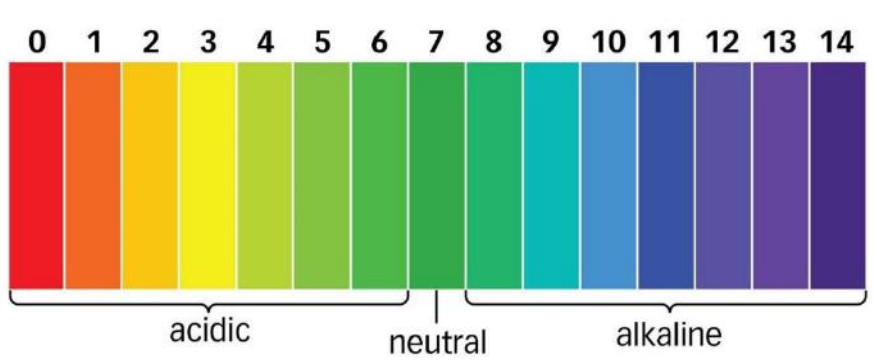|	ANSWER	NOTES
a	↓	Structure of monomer = structure of repeat unit with a C=C instead of –C–C–.
	$$n \; H-\underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-H \longrightarrow \left[\underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}} \right]_n$$	
b (i)	$2C_2H_3Cl + 5O_2 \rightarrow 4CO_2 + 2H_2O + 2HCl$	Order of balancing: $C \rightarrow H \rightarrow O$ $C_2H_3Cl + 2.5O_2 \rightarrow 2CO_2 + 1H_2O + 1HCl$ Multiplying the above equation by 2: $2C_2H_3Cl + 5O_2 \rightarrow 4CO_2 + 2H_2O + 2HCl$
(ii)	Combustion of poly(chloroethene) results in the formation of HCl which mixes with water to form acid rain.	

SECTION B: Q9
(continued from previous page)

	ANSWER	NOTES
c (i)	For making fishing nets / swimwear / athletic wear / ropes	
(ii)		
d	The Copper waste particles stop sliding over each other and start vibrating instead. The arrangement changes from disordered in liquid state to ordered/crystalline in solid state.	
e	Copper has a metallic lattice structure which consists of a lattice of positive Copper ions in a sea of electrons. Strong metallic bonds exist between the lattice of Copper ions and delocalised electrons. A large amount of heat energy is required to break many of these bonds in order to melt the solid, hence high melting point.	

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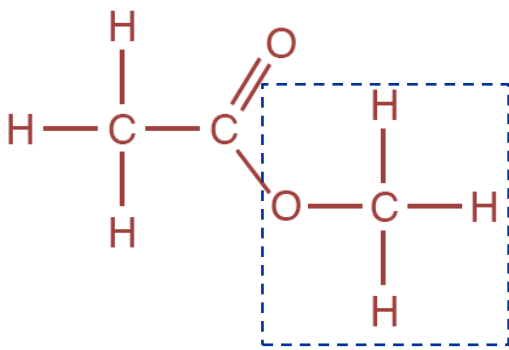
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SECTION B: Q10

	ANSWER	NOTES
a	A hydrocarbon contains only hydrogen and carbon atoms. Cyclobutanol contains Oxygen as well.	
b	Butanoic acid does not have any carbon-carbon double bonds / all the carbon-carbon bonds are single bonds.	
c	**test:** test with Universal indicator **cyclobutanol:** no change in colour **butanoic acid:** change in colour of Universal indicator from green to red / orange	Cyclobutanol is neutral while butanoic acid is weakly acidic.

SECTION B: Q10
(continued from previous page)

	ANSWER	NOTES
d	Molecular formula of Cyclobutanol = C_4H_8O Molar mass of Cyclobutanol = $4 \times 12 + 8 \times 1 + 16 = 72$ g Mass of C in Cyclobutanol = 48 g % by mass of C in Cyclobutanol = $\dfrac{48}{72} \times 100$ = 66.666... % ≈ 66.7 %	
e **(i)**	ethanoic acid / CH_3COOH	Ethanol gets oxidised to Ethanoic acid.
(ii)	(acidified) potassium manganate(VII)	(acidified) Potassium dichromate (VI) can also be used as an oxidising agent.
(iii)	methanol	Step 2 involves esterification of Ethanoic acid with methanol to form methyl ethanoate.

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