SOLUTION TO 5070/21/M/J/19

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SECTION A: Q1		
	ANSWER	**NOTES**
a	$^{39}_{20}Ca$	$^{A}_{Z}X$ A → atomic mass number / nucleon number Z → atomic number X → symbol Atomic number = number of protons in the nucleus of an atom
b	$^{35}_{17}Cl$	A → nucleon number
c	$^{37}_{17}Cl^{-}$	Number of electrons in $^{37}_{17}Cl^{-}$ = 18 Electronic structure = 2.8.8
d	$^{20}_{10}Ne$	Number of neutrons = A – Z Number of neutrons in $^{20}_{10}Ne$ = 20 – 10 = 10
e	$^{64}_{29}Cu$	Cu is a transition metal.

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SECTION A: Q2		
	ANSWER	**NOTES**
a	All elements of Group II have 2 electrons in their outer shell, hence similar chemical properties.	The chemical properties of elements largely depend upon the number of electrons in their outer shell. Elements belonging to the same group have the same number of outer shell electrons, hence similar chemical properties.
b	The atomic radius increases down the group. The melting point decreases from Be to Mg and increases again from Mg to Ca and decreases thereafter. It does not seem to follow a general trend unlike the atomic radius.	
c (i)	2.8	Electronic configuration for: Mg atom = 2.8.2 Mg^{2+} ion = 2.8 Mg^{2+} ion is formed from Mg atom by the loss of 2 electrons from the outer shell.
(ii)	negative electrode: $Mg^{2+} + 2e^- \rightarrow Mg$ positive electrode: $2Cl^- \rightarrow Cl_2 + 2e^-$	
(iii)	Cu^{2+} gets reduced to Cu by gaining electrons from Mg.	**Half-equations:** $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ The electrons lost by Mg are gained by Cu^{2+}.

SECTION A: Q2

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	ANSWER	NOTES
e	Magnesium oxide and Hydrogen	
f	$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$	
g	Excess of Magnesium is added to a solution of warm dilute Hydrochloric acid with stirring. $Mg(s) + HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ The mixture is filtered to remove the excess Magnesium. 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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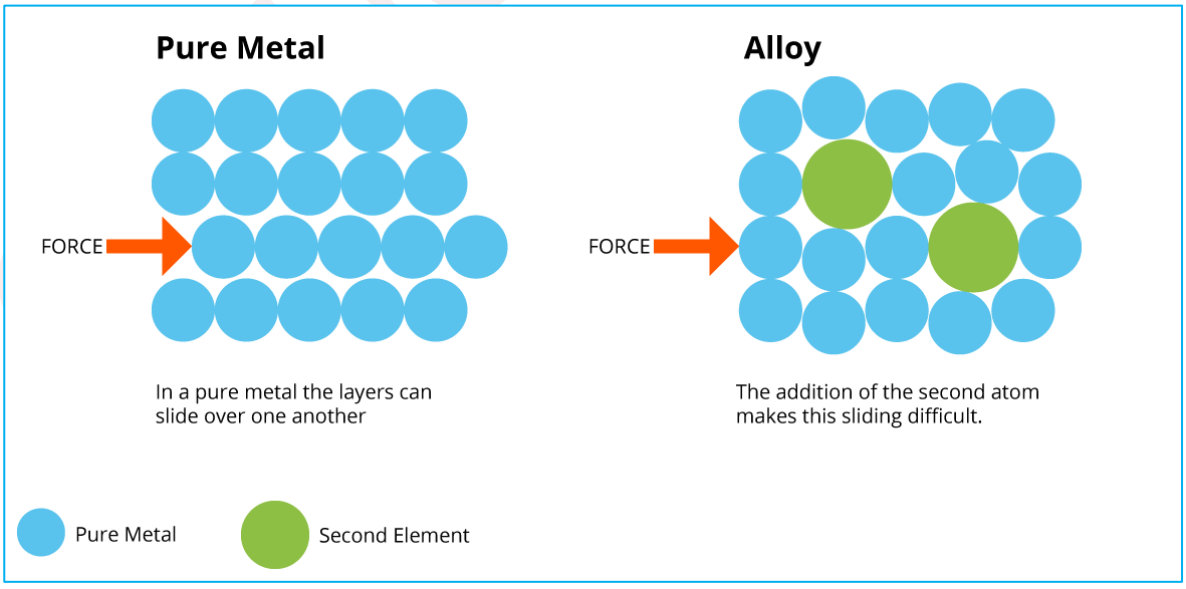
SECTION A: Q3

	ANSWER	NOTES
a	high melting point / high boiling point / high density / good conductor of electricity / good conductor of heat / malleable / ductile / hard / strong / sonorous	Transition metals are typical metal. All physical properties of typical metals apply to transition metals.
b	Molybdenum compounds are coloured. Some Molybdenum compounds may have catalytic activity. Molybdenum may exist in variable oxidation states in its compounds.	
c	Molybdenum steel has atoms/ions of different sizes. The layers of metal ions cannot slide easily over each other unlike those in pure Iron. This makes it less malleable / much harder than pure Iron.	



SECTION A: Q3

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	ANSWER	NOTES
d	% by mass of Mo in Mo-steel = 20.0% Mass of Mo in 1000 g of Mo-steel = 200 g **Mole ratio** 1 mol of MoO_3 : 1 mol of Mo **Mass ratio** 144 g of MoO_3 : 96 g of Mo x g of MoO_3 : 200 g of Mo $x = \frac{200 \times 144}{96} = 300$ Mass of MoO_3 = 300 g	Relative atomic mass of: Mo = 96 O = 16 Relative molecular mass of: $MoO_3 = 96 + 16 \times 3 = 144$

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SECTION A: Q4		
	ANSWER	**NOTES**
a	percentage by volume of nitrogen in dry air = 78%	
b	Separation of oxygen, nitrogen and the noble gases from liquid air is carried out by fractional distillation as they have different boiling points. Liquid air is vaporised and introduced into the fractionating column. The vapours cool and condense as they rise up the column. Different vapours condense at different levels depending upon their boiling points. Vapours with a higher boiling point come off at the bottom while the ones with lower boiling points exit from the top.	
c	used to make fertilisers used to make ammonia	
d (i)	sulfur dioxide / nitrogen dioxide	sulfur dioxide and nitrogen dioxide are acidic oxides that dissolve in rain-water to form acid rain.
(ii)	Carbon dioxide is a greenhouse gas. An increase in the percentage of carbon dioxide in the air leads to global warming.	Effects of Global warming: melting of ice-caps, rise in sea-level, flooding

SECTION A: Q4

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	ANSWER	NOTES
d (iii)	Source of CO in air: incomplete combustion of fossil fuels / organic matter	

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SECTION A: Q5

	ANSWER	NOTES
a		

	C	H	O
mass/100 g	1.68	0.14	4.48
A_r	12	1	16
n	$\frac{1.68}{12}$ = 0.14	$\frac{0.14}{1}$ = 0.14	$\frac{4.48}{16}$ = 0.28
Mole ratio	$\frac{0.14}{0.14}$ = 1	$\frac{0.14}{0.14}$ = 1	$\frac{0.28}{0.14}$ = 2
Empirical formula	**CHO_2**		

b	V (KOH) = 12.7 cm^3 = 0.0127 dm^3 n (KOH) = 0.0127 x 0.150 = 0.001905 **mole ratio** 1 mole of U : 2 moles of KOH n (U) = 0.001905 × 0.5 = 0.0009525 relative formula mass of U $= \frac{0.086}{0.0009525}$ = 90.3 ≈ 90	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 U = 12 + 1 + 32 = 45 Relative formula mass of U = 90 $\frac{90}{45}$ = 2 Molecular formula of U = $(CHO_2)_2$ = $C_2H_2O_4$	

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SECTION A: Q6		
	ANSWER	**NOTES**
a	Acid is a substance which dissociates in an aqueous solution to form Hydrogen ions, H^+.	
b	Weak indicates an acid that does not dissociate completely / partial ionisation in water / little dissociation.	
c	Universal indicator paper can be dipped in a solution of dilute propanoic acid. The colour seen can be compared against the Universal indicator colour chart which indicates the pH.	
d	• Liming of soil to reduce soil acidity • Flue gas desulfurization (removal of Sulfur dioxide from flue gases by neutralization)	
e	Bond breaking is endothermic and bond making is exothermic. More energy is released in bond forming than energy absorbed in bond breaking in the reaction of Calcium oxide with water.	

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SECTION B: Q7		
	ANSWER	**NOTES**
a	Ammonium carbonate has decomposed completely when no more of the white solid is left in the tube.	
b	Molar mass of ammonium carbonate = 96 g n (ammonium carbonate) = $\frac{4.80}{96}$ = 0.05 **mole ratio** 1 mol of ammonium carbonate : 3 mol of ammonia and carbon dioxide 0.05 mol of ammonium carbonate : 3 × 0.05 mol of ammonia and carbon dioxide Total moles of ammonia and carbon dioxide = 0.15 Total volume of ammonia and carbon dioxide = 0.15 × 24 = 3.6 dm^3	Molar mass of ammonium carbonate = 2 (14 + 4 × 1) + 12 + 3 × 16 = 96 g 1 mol of a gas at room temperature and pressure occupies 24 dm^3.
c	**Test:** heat the sample with aqueous sodium hydroxide **result:** gas released turns damp red litmus blue	When a sample containing ammonium ions is heated with Sodium hydroxide, ammonia gas is released. Ammonia is basic, hence turns damp red litmus blue.

SECTION B: Q7 (continued from previous page)		
	ANSWER	**NOTES**
d	$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$	**Chemical equation:** $Na_2CO_3\ (aq) + 2HCl\ (aq)$ $\rightarrow 2NaCl\ (aq) + CO_2(g) + H_2O(l)$ **Ionic equation:** ~~$2Na^+$~~ $(aq) + CO_3^{2-}(aq) + 2H^+(aq) +$ ~~$2Cl^-$~~(aq) $\rightarrow$ ~~$2Na^+$~~ $(aq) +$ ~~$2Cl^-$~~$(aq) + CO_2(g) + H_2O(l)$ **Net Ionic equation after eliminating the spectator ions:** $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$
e	In solid ammonium carbonate, 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.	

SECTION B: Q8		
	ANSWER	**NOTES**
a	When a reversible reaction in a closed system attains a state wherein the rate of the forward reaction becomes equal to the rate of the backward reaction, dynamic equilibrium is attained.	
b	**Prediction:** more of PCl_5 will be formed or the concentration of PCl_5 in the equilibrium mixture will increase **Explanation:** Increase in pressure favours the side with fewer moles of gas. In this case, the equilibrium shifts to the left, hence more of PCl_5 is formed.	
c (i)	The forward reaction is endothermic. Increase in temperature favours the endothermic reaction more than the exothermic reaction, hence equilibrium shifts to the right.	
(ii)	Increase in temperature increases the average kinetic energy of the reacting particles. The particles move faster and collide more often (collision rate increases). A greater proportion of particles collide with an energy ≥ activation energy. The frequency of successful collisions increases resulting in faster reaction.	

SECTION B: Q8

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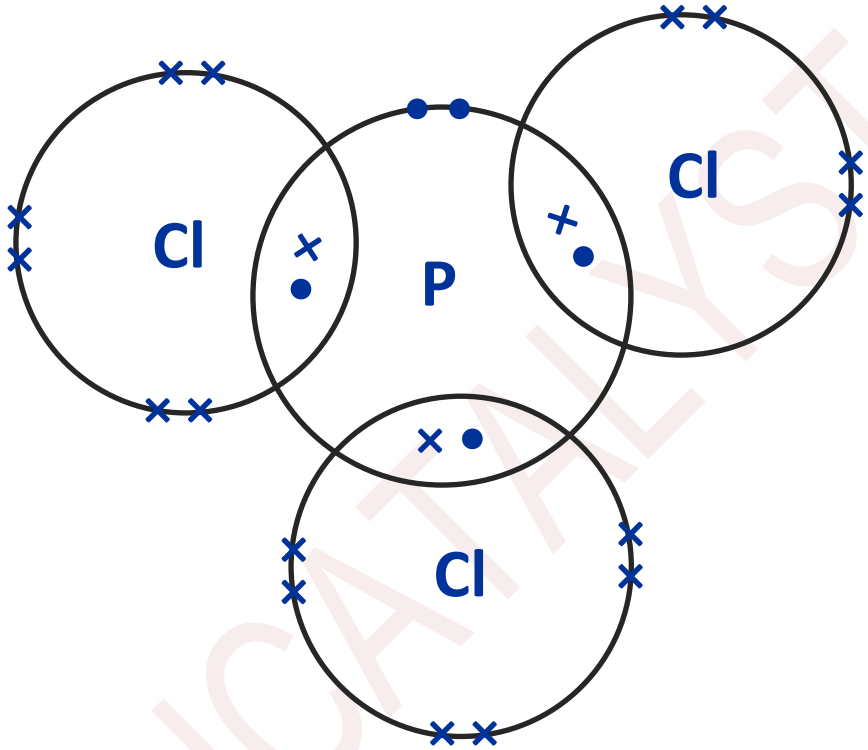
	ANSWER	NOTES
d	↓	
		
e	$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$	

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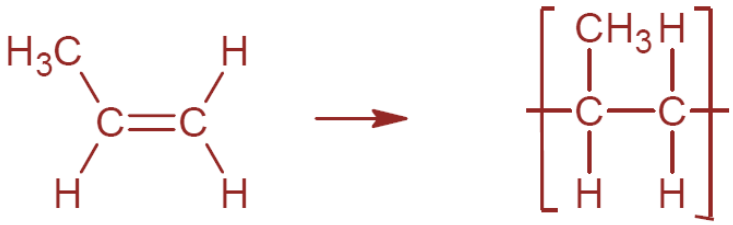
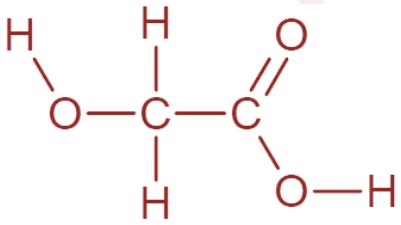
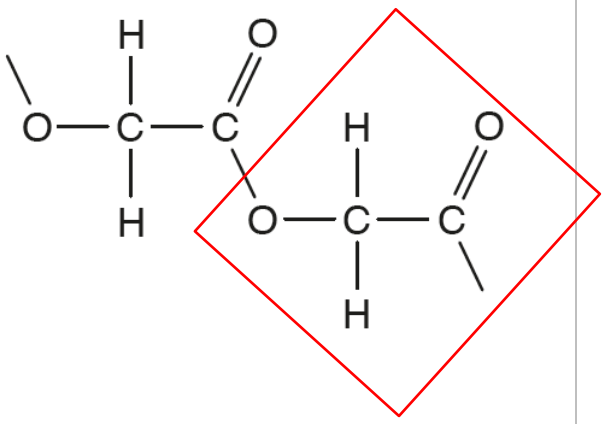
SECTION B: Q9

	ANSWER	NOTES
a	↓	Structure of repeat unit = structure of monomer with a –C–C– instead of C=C
		
b	$2CH_2 + 3O_2 \rightarrow 2CO_2 + 2H_2O$	Complete combustion of hydrocarbons always produces carbon dioxide and water. Order of balancing: C → H → O
c (i)	A biodegradable plastic will get decomposed / decayed. It will not use up landfill space unlike non-biodegradable plastic waste.	
(ii)		 **Repeat unit**

SECTION B: Q9

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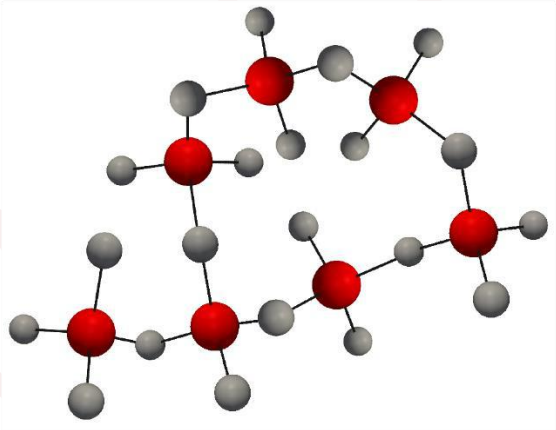
	ANSWER	NOTES
d	The movement of glass particles changes from vibratory in solid glass waste to particles sliding over each other in molten glass. The arrangement changes from ordered/crystalline to disordered.	
e	Sand has a macromolecular (giant covalent) structure where all atoms are held together in a lattice structure by an extensive network of strong covalent bonds. A large amount of heat energy is required to break these bonds in order to melt the solid, hence high melting point.	

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SECTION B: Q10		
	ANSWER	**NOTES**
a	A hydrocarbon contains only hydrogen and carbon atoms.	
b	They have the same molecular formula (C_4H_8) but different structures.	
c	**test:** Add aqueous bromine **cyclobutane:** orange colour persists / no change in colour of aqueous bromine **butene:** aqueous bromine gets decolourised / change in colour from orange to colourless	Butene reacts readily with bromine to form 1,2–dibromo butane which is colourless. Bromine (aq) gets decolourised as it reacts. Cyclobutane does not react with aqueous Bromine.
d	Molar mass of Butene $= 4 \times 12 + 8 \times 1 = 56$ g Mass of C in Butene = 48 g % by mass of C in Butene $= \frac{48}{56} \times 100$ $= 85.7\ \%$ $\approx 86\ \%$	

SECTION B: Q10 (continued from previous page)		
	ANSWER	**NOTES**
e (i)	Ethanol / CH_3CH_2OH	
(ii)	Steam / Superheated steam	
(iii)	(acidified) potassium manganate (VII) or (acidified) potassium dichromate (VI)	

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