H2 Chemistry 9647

2013 'A' Level P1 Worked Solutions

1 Two H₂O molecules are eliminated when three H₃PO₄ molecules undergo condensation.

The molecular formula of triphosphoric acid produced can be deduced by constructing a balanced chemical equation as shown:

 $3H_3PO_4 \longrightarrow H_5P_3O_{10} + 2H_2O$

<u>*FYI*</u>: A water molecule is eliminated between two H_3PO_4 molecules as shown:



2 ${}^{2}_{1}D, {}^{1}_{1}H, {}^{16}_{8}O, {}^{14}_{7}N$

	D ₃ O ⁺	H₃O⁺	$\rm NH_2^-$	OD-
no. of protons	3 + 8 = 11	3 + 8 = 11	7 + 2 = 9	8 + 1 = 9
no. of electrons	3 + 8 – 1 = 10	3 + 8 – 1 = 10	7 + 2 + 1 = 10	8 + 1 + 1 = 10
no. of neutrons	3 + 8 = 11	0 + 8 = 8	7 + 0 = 7	8 + 1 = 9

3

	C+	Ν	Si⁻	P ⁺
no. of electrons	5 + 1 = 6	7 + 1 = 8	15 + 1 = 16	14 + 1 = 15
on gaining an e⁻				
electronic	1s² 2s² 2p²	1s² 2s² 2p4	1s ² 2s ² 2p ⁶ 3s ²	1s ² 2s ² 2p ⁶ 3s ²
config.			3p ⁴	3p ³

- 4 Largest increase from 4^{th} to 5^{th} I.E (4550 kJ mol⁻¹)
 - $\Rightarrow 5^{\text{th}}$ electron is removed from the next inner quantum shell
 - \Rightarrow 4 electrons in outermost (valence) shell
 - \Rightarrow M is a Group 4 element
 - \Rightarrow M forms a chloride with formula **MC***l*₄
- 5 Solid graphite (giant covalent) conducts electricity (due to presence of delocalised e⁻).
- 6 The behaviour of a gas is most ideal at **low pressure** and **high temperature**.

At low pressure, the gas molecules are far apart. The volume of the gas molecules therefore becomes insignificant compared to the volume of container. Similarly, the intermolecular forces of attraction are negligible.

At high temperature, the gas molecules move faster (higher K.E.) and the intermolecular forces of attraction become negligible.

В

В



D

С

Α

С

7 Α $\Delta H_{\rm f} = \Sigma \Delta H_{\rm f}$ (products) – $\Sigma \Delta H_{\rm f}$ (reactants) reactants: $CH_3CO_2Na(aq)$ and $H_2O(I)$ products: CH₃CO₂Na.3H₂O(s) В 8 Temperature falls \Rightarrow endothermic reaction, i.e. ΔH is positive Vigorous reaction occurs \Rightarrow reaction is spontaneous, i.e. ΔG is negative Since $\Delta G = \Delta H - T \Delta S$ $-T\Delta S = \Delta G - \Delta H$ $T\Delta S = -(\Delta G - \Delta H)$ $\therefore \Delta S$ must be positive as $-(\Delta G - \Delta H)$ is always positive. Au³⁺ + 3e⁻ → Au 9 D n(Au) = 6.0 / 197.0 = 0.03045 mol $n(e^{-}) = 3 \times 0.03045 = 0.09135 \text{ mol}$ $Q = n_e F = 0.09135 \times 96500 = 8815 C$ t = Q/I = 8815 / 0.10 = 8.8 x 10⁴ s **10** Ionic product of CaCO₃ = $[Ca^{2+}][CO_3^{2-}] = 0.10 \times 1 \times 10^{-9}$ С = 1 x 10⁻¹⁰ < K_{sp} (CaCO₃) \Rightarrow no ppt lonic product of $FeCO_3 = [Fe^{2+}][CO_3^{2-}] = 0.10 \times 1 \times 10^{-9}$ = 1 x 10⁻¹⁰ > $K_{sp}(FeCO_3) \Rightarrow ppt$ forms

lonic product of MnCO₃ = [Mn²⁺][CO₃²⁻] = 0.10 x 1 x 10⁻⁹ = 1 x 10⁻¹⁰ > K_{sp} (MnCO₃) \Rightarrow ppt forms

: FeCO₃ and MnCO₃ only are precipitated.

- 11 $[H^+] = [OH^-]$ at <u>all</u> temperatures for a neutral solution
 - Position of equilibrium (POE) lies furthest to the right (towards ionisation of water) at <u>50 °C</u> since K_w at this temperature is the largest (since the larger the K_w, the greater the extent of ionisation of water)

D

- When temperature increases, K_w increases
 ⇒ POE is shifted to the right; forward reaction is favoured
 Increase in temperature favours endothermic reaction to absorb the extra heat
 ⇒ forward reaction is endothermic
- ... Options A–C are incorrect.

 $K_{w} = [H^{+}][OH^{-}] = [H^{+}]^{2}$ (since $[H^{+}] = [OH^{-}]$ at all temperatures) $[H^{+}] = (K_{w})^{1/2}$

As temperature increases, K_w increases

- \Rightarrow [H⁺] increases
- \Rightarrow pH decreases (since pH = -log₁₀[H⁺])
- \Rightarrow neutral pH of water at higher temperatures is <7.

12 $NO_2(g) + SO_2(g) \longrightarrow NO(g) + SO_3(g)$ $NO(g) + \frac{1}{2}O_2(g) \longrightarrow NO_2(g)$ $(NO_2 \text{ is regenerated at the end of the reaction})$

 $SO_3(g)$ formed reacts with rain water to give very dilute sulfuric acid (acid rain) $SO_3(g) + H_2O(I) \longrightarrow H_2SO_4(aq)$

C. NO_2 catalyses the formation of ozone; NO causes ozone depletion. D. N_2O is a greenhouse gas.

13 electrical conductivity Na Mg Al Si P S Cl Na Mg Al Si P S Cl

Ionisation energy generally increases across the Period.

.: Options A–C are incorrect.



14 Metals are electrical conductors as their metallic lattices contain delocalised electrons which can D act as mobile charge carriers. Hence, the greater the number of delocalised electrons the greater the electrical conductivity.

The electrical conductivity of A*l* is greater than that of Mg as each A*l* atom contributes three valence electrons to the 'sea' of delocalised electrons while each Mg atom only contributes two valence electrons.

The electrical conductivity of Cu (transition metal) is greater than that of Ca (s–block metal) as the 3d and 4s electrons in Cu can be delocalised for metallic bonding since the 3d and 4s orbitals in Cu are similar in energy level. Each Ca atom only contributes two valence electrons to the 'sea' of delocalised electrons.

В

D



 $\begin{array}{cccc} & \mathsf{Fe}^{2+} & \overset{\mathsf{KMnO}_4}{\longrightarrow} & \mathsf{Fe}^{3+} & + & \mathsf{Mn}^{2+} \\ & \mathsf{pale green} & & \mathsf{pale yellow} & \mathsf{colourless} \end{array}$

A <u>redox reaction</u> occurs between acidified $Fe^{2+}(aq)$ and $KMnO_4(aq)$. As $KMnO_4(aq)$ is added until in large excess, the solution **in the conical flask** changes from **pale green to pink**, **and finally purple**.

В

D



The ppt appears more yellow as the white AgCl ppt dissolves on addition of excess conc. NH_3 . Note: AgI is insoluble in conc. NH_3 .

- **18** D. X can be either P or S only (Period 3).
 - B. X is P since chloride of sulfur is not in syllabus.
 - C. This is a correct statement if X is P.

: Element X is deduced to be phosphorus, P

A. $PCl_3 + 3H_2O \longrightarrow H_3PO_3(aq) + 3HCl(aq)$ $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(I)$ $2NaOH(aq) + H_3PO_3(aq) \longrightarrow Na_2HPO_3(aq) + 2H_2O(I)$

White ppt is not produced.

- B. $PCl_3 + Cl_2 \longrightarrow PCl_5$
- C. P is a solid at room temperature.
- D. $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ (phosphoric acid)

19



yanucamide B



С

Α

С



I-Cl bond is polarised; Cl being more electronegative than I

By pattern recognition,



propene

Alternatively, by Markovnikov's rule:



С

- 23 A. n(C₂H₃OC*l*) = 1 / 78.5 = 0.01273 mol n(C*l*⁻) produced from hydrolysis with NaOH(aq) = 0.01273 mol n(AgC*l*) produced = 0.0127 mol
 - B. $n(C_6H_{10}Cl_2) = 1 / 153 = 6.536 \times 10^{-3} \text{ mol}$ $n(Cl^{-})$ produced from hydrolysis with NaOH(aq) = 2 x 6.536 x 10^{-3} = 0.01307 \text{ mol} n(AgCl) produced = **0.0131 mol**



does not undergo hydrolysis (nucleophilic substitution) with OH-

- C.
- D. $n(C_4H_4O_2Cl_2) = 1 / 155 = 6.452 \times 10^{-3} \text{ mol}$ $n(Cl^-)$ produced from hydrolysis with NaOH(aq) = 2 x 6.452 x 10^{-3} = 0.0129 \text{ mol} n(AgCl) produced = 0.0129 mol



Order of increasing Mr: Q, P, R



gives positive *Tri–iodomethane Test* (produces pale yellow ppt with alkaline aq. I₂)



26 A. Absence of an amide group



В

27 A. 4 mol of $PCl_5(s)$

- B. 1 mol of HCl(g) in the presence of $ZnCl_2$
- D. 3 mol of NaOH(aq)



С

С

Α

D

Α





30 Not in syllabus.

28

The lack of a hydrogen atom on Proline's nitrogen prevents it from participating in hydrogen bonding. In addition, Proline destabilises the α -helix because of its irregular geometry; its R-group bonds back to the nitrogen of the amide group, which causes steric hindrance

31
$$C_6H_{10}S + 19/2O_2 \longrightarrow 6CO_2 + SO_2 + 5H_2O$$

- 1. $n(C_6H_{10}S) = 0.10 / 114 = 8.772 \times 10^{-4} \text{ mol}$ $n(CO_2) = 6 \times 8.772 \times 10^{-4}$ mass of CO₂ = 6 x 8.772 x 10⁻⁴ x 44.0 = 0.23 g
- 2. $n(SO_2) = 8.772 \times 10^{-4} \text{ mol}$ volume of SO₂ at r.t.p = 8.772 x 10⁻⁴ x 24 = 0.021 dm³ = 21 cm³



Mass of product = $8.772 \times 10^{-4} \times 433.7 = 0.380 \text{ g}$

32 Homogeneous catalysis is a sequence of reactions that involve a catalyst in the same phase as D the reactants.
 Catalyst: Br• radicals
 Reactants: Br₂ & CH₄

- The hydrogen gas was passed into an aqueous solution in the diagram and so there was no C need for the gas to be dried first.
 - 2. All aqueous solutions should be at a concentration of 1.0 mol dm^{-3} (standard conditions)
 - 3. Pt is inert

- 1. MO₂ undergoes <u>disproportionation</u> (a redox reaction) O in MO₂ is reduced and oxidised simultaneously
- 2. O_2^{2-} (peroxide ion) contains <u>18</u> (8 + 8 + 2) electrons.
- 3. M²⁺ O₂²⁻ M²⁺ O²⁻

L.E α (Z⁺ Z⁻) / (r₊ + r₋)

 Z^+ , Z^- and r_+ are the same for both MO₂ and MO

But r_- of O_2^{2-} is larger than that of $O^{2-} \Rightarrow L.E.$ of MO_2 is <u>less exothermic</u> than that of MO

- Ionic radius of M²⁺ ion increases down Group 2 from Ca to Ba due to increase in number of D electron shells down the group
 - 2. $\Delta H_{hyd} \propto Z^+ / r_+ \Rightarrow r_+$ increases down Group 2 \Rightarrow magnitude of ΔH_{hyd} decreases
 - 3. Energy required for the process M(g) → M²⁺(g) + 2e⁻ is the summation of first and second ionisation energies of M
 ⇒ since I.E. decreases down Group 2, the energy required for the above process decreases down the group from Ca to Ba
- **36** In is a Group **13** element.

В

Comparing the chemical properties of In with a familiar Group 13 element, A*l*, the following deductions can be made:

- 1. Like $AlCl_3$, $InCl_3$ dimerises in the vapour phase to form In_2Cl_6
- 2. Like Al_2O_3 , the oxide of In dissolves in aqueous acid
- 3. Group 13 ions are not coloured



3 $CH_3CH_2COCl + NH_3 \rightarrow CH_3CH_2CONH_2 + HCl$

nucleophilic acyl substitution of acyl chloride