2024 JC2 Preliminary Examination H1 Chemistry 8873 Paper 1 Worked Solution

1
$$n_{H_2O} = \frac{3.6}{16.0 + 2 \times 1.0} = 0.200 \text{ mol}$$

 $n_{NH_3} = n_{HCl} = \frac{100}{1000} \times 1.0 = 0.100 \text{ mol}$
 $n_{N_2O_y} : n_{NH_3} : n_{H_2O} = 0.10 : 0.10 : 0.20 = 1 : 1 : 2$
 $x = 1, y = 2$
 $\Rightarrow \mathbf{B}$

$$\mathbf{2} \quad \mathbf{A} = \frac{1}{5} \times 10 + \frac{4}{5} \times 11 = 10.8$$
$$\Rightarrow \mathbf{C}$$

reaction 1: $H_2 \stackrel{-1}{O}_2 \stackrel{[R]}{\longrightarrow} H_2 \stackrel{-2}{O}$ reaction 2: $H_2 \stackrel{-1}{O}_2 \stackrel{[O]}{\longrightarrow} \stackrel{0}{O}_2 (H_2O \text{ from MnO}_4)$ reaction 3: $H_2 \stackrel{-1}{O}_2 \stackrel{[R]}{\longrightarrow} H_2 \stackrel{-2}{O} ; H_2 \stackrel{-1}{O}_2 \stackrel{[O]}{\longrightarrow} \stackrel{0}{O}_2$ $\Rightarrow \mathbf{B}$

particle	no. of <i>p</i>	no. of <i>e</i> ⁻
P⁻	40–21 = 19	19+1 = 20
Q⁺	38–18 = 20	20–1 = 19
R ^{2–}	39–19 = 20	20+2 = 22
S ²⁺	41–20 = 21	21–2 = 19

 \Rightarrow B

4

5 angle of deflection,
$$\theta \propto \frac{q}{m} \Rightarrow \theta = k \left(\frac{q}{m}\right)$$

For ¹H⁺: +15^o =
$$k \left(\frac{+1}{1}\right) \Rightarrow k = +15^{o}$$

A*: $\theta = (+15^{o}) \left(\frac{+1}{2}\right) = +7.5^{o}$
B*: $\theta = (+15^{o}) \left(\frac{+2}{3}\right) = +10^{o}$
C*: $\theta = (+15^{o}) \left(\frac{+2}{6}\right) = +5^{o}$
D*: $\theta = (+15^{o}) \left(\frac{+3}{12}\right) = +3.75^{o}$

 \Rightarrow C

6



 $\Rightarrow \mathbf{B}$

8 Due to smaller size of the F atom, its orbitals are more compact and hence there is greater effective overlap between the orbitals, leading to shorter F–F bond length. This should result in a stronger F–F bond. However, due to the short F–F bond, the lone pairs of electrons on the two F atoms are very close, resulting in severe repulsion between them, causing the F–F bond to be weaker.

Despite F having a smaller nuclear charge than Cl, Cl has more core electrons than F that confers shielding, nullifying the larger nuclear charge of Cl.

$\Rightarrow \mathbf{A}$

9 HC*l* and HBr have a simple molecular structure.

Boiling point of simple molecule is dependent on the strength of the intermolecular forces of attraction.

HCl and HBr do not possess H bonding, which requires H bonded to F, O or N.

Due to Br having more electrons than C*l*, the electron cloud of HBr is larger and more polarisable than that of HC*l*. This leads to stronger instantaneous dipole-induced dipole attractions between HBr molecules, imparting higher boiling point.

- $\Rightarrow \mathbf{D}$
- 10 A√: As *T* increased, amount of A remaining at equilibrium increased. This shows that position of equilibrium shifts left, hence backward reaction is endothermic. Forward reaction is thus exothermic.
 - B✓: Because strong acids and bases are fully ionised in water, the enthalpy change of neutralisation will be almost identical, as it refers to the heat evolved when H⁺(aq) reacts with OH⁻(aq) to give 1 mole of H₂O(1).
 - C≭: Third I.E. of Al should be the energy needed to convert 1 mole of Al²⁺(g) into 1 mole of Al²⁺(g).
 - D✓: Lattice energy involves the formation of ionic bonds between gaseous cations and gaseous anions, giving 1 mole of the crystalline ionic lattice, and so is always exothermic.
 - \Rightarrow C
- 11 Using Hess' Law

$$\Delta H_1 = -26.8 - 2(-16.5) \text{ kJ mol}^{-1}$$

= +6.2 kJ mol^{-1}

 \Rightarrow D

12 1√: Ultraviolet light provides the energy needed to break the O–O bond to generate O free radicals:

$$0 \stackrel{0}{=} 0 \stackrel{uv}{\longrightarrow} 0 = 0 + 0$$

 $2\checkmark$: Adding up the second and third eqns:

$O_3 + O \rightarrow 2O_2$

NO catalyses the reaction between O_3 and O.

3*: NO itself is oxidised by O₃ to NO₂ in the second equation, hence acting as a reducing agent.



14 A catalyst decreases the activation energy of the forward and backward reaction by the same amount, *C*. Hence rate constant, for the forward and backward reaction

increases by the same factor, $e^{\frac{C}{RT}}$:

$$k = Ae^{\frac{E_{a}-C}{RT}} = Ae^{\frac{-E_{a}+C}{RT}} = \left(e^{\frac{C}{RT}}\right) \left(Ae^{\frac{-E_{a}}{RT}}\right)$$
$$\Rightarrow \mathbf{B}$$

15 1√: As reaction is exothermic, the eqm shifts left to absorb heat when temperature increases, causing the yield to decrease.

> Rate of both forward and backward reaction increases (but to different extent) since the rate constant of both forward and backward reaction increases (by different factor).

2*: Increase in [H₂S] causes the eqm to shift right by LCP, thereby leading to an increase in yield.

The rate of forward reaction will increase with $[H_2S]$.

3√: Pressure ∞ concentration. Rate of reaction decreases with pressure.

When pressure decreases, eqm shifts to the left with more *gaseous* particle, leading to a decrease in yield.

$$\Rightarrow$$

16
$$\mathbf{A}\mathbf{v}$$
: $\mathcal{K}_{c} = \frac{[CO_{2}][H_{2}]^{2}}{[CH_{4}][H_{2}O]^{2}} = \frac{0.1 \times 0.1^{4}}{0.1 \times 0.1^{2}} = 0.01$
 $\mathbf{B}\mathbf{x}$: $\mathcal{K}_{c} = \frac{[NH_{3}]^{2}}{[N_{2}][H_{2}]^{3}} = \frac{0.1^{2}}{0.1 \times 0.1^{3}} = 100$
 $\mathbf{C}\mathbf{x}$: $\mathcal{K}_{c} = \frac{[HI]^{2}}{[H_{2}][I_{2}]} = \frac{0.1^{2}}{0.1 \times 0.1} = 1$
 $\mathbf{D}\mathbf{x}$: $\mathcal{K}_{c} = \frac{[N_{2}O_{4}]}{[NO_{2}]^{2}} = \frac{0.1}{0.1^{2}} = 10$
 $\Rightarrow \mathbf{A}$

- 17 A≭: Na₂CO₃ is a Brønsted base as it accepts H⁺ from HC*l*.
 - B≭: NH₃ is a Brønsted base as it accepts H⁺ from HNO₃.
 - C≭: H₂O is a Brønsted base as it accepts H⁺ from HC*L*
 - D✓: KOH is an Arrhenius base as it contains a OH group and undergoes dissociation to give OH⁻ ions, which then reacts with the H⁺ from HNO₃.

 \Rightarrow D

18 $n_{\rm H_2SO_4} = \frac{20}{1000} \times 0.1 = 0.00200 \text{ mol}$

$$n_{\rm NaOH} = \frac{00}{1000} \times 0.1 = 0.00800 \text{ mol}$$

$$\begin{split} \text{H}_2\text{SO}_4 + 2\text{NaOH} &\rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \\ n_{\text{NaOH}} \text{ remaining} = 0.00800 - 2 \times 0.00200 \\ &= 0.00400 \text{ mol} \end{split}$$

$$\left[OH^{-}\right] = \frac{\frac{0.00400}{20+80}}{\frac{1000}{1000}} = 0.0400 \text{ mol } dm^{-3}$$

$$pH = 14 - pOH = 14 + lg[OH^{-}]$$
$$= 14 + lg(0.0400) = 12.6$$

⇒B

19 The major buffer in human blood is the H_2CO_3/HCO_3^- buffer.

Since lactic acid is produced during exercise, to maintain the pH, H_3O^+ from lactic acid must be removed by the HCO_3^- .

⇒ C

- 20 A*: Atomic radius generally decreases across Period 3 as the shielding remains constant while nuclear charge increases, resulting to an increase in effective nuclear charge.
 - B≭: Na, Mg and A/ are metals with high electrical conductivity, while Si is a metalloid with low conductivity.
 - C★: Although first I.E. generally increase across Period 3. However, there is a dip in first I.E. at Group 13 (as electrons are removed from 3p rather than 3s orbital) and Group 16 (due to interelectronic repulsion between pair 3p electrons).
 - D✓: Melting point increases from Na to Al as the number of delocalised electrons increase leading to stronger metallic bonds. Si has a giant molecular structure with strong Si–Si bond in a lattice structure, imparting the highest melting point.

 \Rightarrow D

- **21** 1*: A lCl_3 but not A l_2O_3 hydrolyses in water.
 - 2*: Al₂O₃ being an amphoteric oxide reacts with HCl. However, AlCl₃ does not react with HCl.
 - 37: Al_2O_3 is ionic but $AlCl_3$ is simple covalent.

 \Rightarrow D

22 The stronger the halide ion as a reducing agent, the larger the number of halogen it can reduce.

 X^- can reduce both Y_2 and Z_2 , while Z^- can only reduce Y_2 , and Y^- cannot reduce any of the halogen. Hence X^- is the strongest, while Y^- is the weakest reducing agent.

⇒B

23 Butanone and butanal are constitutional isomers, so they must have the same empirical and molecular formula, only differing in their structures, *i.e.* structural and skeletal formula, which shows that they are different compounds.

⇒ B

24 Alkanes' 'lack of affinity' is due to the molecules being non-polar, hence do not attract negative nucleophiles nor positive electrophiles, and is unreactive.

 \Rightarrow C

25 A√: Combustion

 $2CH_3CH_2CH_2OH + 9O_2 \rightarrow 6CO_2 + 8H_2O$

heat

ÓН





- 29 A*: Hydrogen bonds required H bonded to F, O or N, which is not present in the polyester chain.
 - B✓: Softening of a thermoplastic involves weakening of the intermolecular forces of attraction between the chains, which in these case are instantaneous dipole-induced dipole and permanent dipole-permanent dipole attractions (due to polar ester -CO₂- group).
 - **C***: Softening of a thermoplastic does not involve breaking the covalent bonds.
 - **D***: Softening of a thermoplastic does not involve breaking the covalent bonds.

\Rightarrow B

- **30** Nanoparticles are materials which have structured components with at least one dimension in the size range between 1 and 100 nm.
 - 1*****: 8.7 μ m = 8700 nm; 2.2 μ m = 2200 nm
 - 2√: 50 nm is between 1 and 100 nm
 - 3**ະ**: 2.5 μm = 2500 nm
 - 4**ະ**: 0.5 μm = 500 nm

⇒ A

Answer Key Qn Ans Qn Qn Ans Ans В D 21 D 1 11 2 С В 22 В 12 3 В 13 С 23 В 4 В 14 в 24 С 5 С 15 А 25 С 6 С 16 А 26 D 7 D С В 17 27 С 8 A 18 В 28 С 9 D 19 29 В 10 С 20 D 30 А