Eunoia Junior College 9729 H1 Chemistry 2023 Paper 1 Suggested Solution

- A ✓: The relative charge of a proton, +1, is −1 times the relative charge of an electron, −1.
 - **B ***: A proton has a relative charge of +1, while a neutron has no charge.
 - **C***: The relative mass of an electron is $\frac{9.11 \times 10^{-31}}{1.67 \times 10^{-27}} = \frac{1}{1833} \approx \frac{1}{2000} \text{ times}$

the relative mass of a neutron .

 D *: The relative masses of protons and neutrons are the same, which are about 200 times the relative mass of an electron.

 $\Rightarrow \mathbf{A}$

2

		3s		Зр		
Al	1s ² 2s ² 2p ⁶	$\uparrow\downarrow$	↑			1
Si	1s ² 2s ² 2p ⁶	$\uparrow\downarrow$	↑	↑		2
Р	1s ² 2s ² 2p ⁶	$\uparrow\downarrow$	↑	↑	↑	3
⇒А						1

3 Rate of reaction is affected by the rate constant which in turn, is affected by the activation energy of the reaction. The lower the activation energy, the higher the rate constant, the faster the reaction.

The C–C*l* bond is more polar than the C–I bond as C*l* is more electronegative than I. We would expect chloroethane to react faster with the negatively charged OH^- in view of the polarity, which is not the case.

Thus, the weaker C–I bond (240 kJ mol⁻¹) compared to C–C*l* bond (340 kJ mol⁻¹) must have lowered the activation energy sufficiently to render the reaction of iodoethane faster

 \Rightarrow D

 $\begin{array}{ll} \textbf{4} & P_4 + \textbf{a} HNO_3 \rightarrow \textbf{4} H_3PO_4 + \dots H_2O + \dots NO_2 \\ P_4 + \textbf{a} HNO_3 \rightarrow \textbf{4} H_3PO_4 + \dots H_2O + \textbf{a} NO_2 \\ P_4 + \textbf{a} HNO_3 \rightarrow \textbf{4} H_3PO_4 + (\textbf{a}-16) \ H_2O + \textbf{a} NO_2 \\ \text{Balancing the number of H:} \\ \textbf{a} = 12 + 2(\textbf{a}-16) \\ \textbf{a} = 20 \\ \text{HNO}_3 + \textbf{b} HBr \rightarrow \frac{\textbf{b}}{2} \ Br_2 + \dots H_2O + \dots NO \\ \text{HNO}_3 + \textbf{b} HBr \rightarrow \frac{\textbf{b}}{2} \ Br_2 + \dots H_2O + \textbf{1} NO \end{array}$

HNO₃ + **b**HBr $\rightarrow \frac{\mathbf{b}}{2}$ Br₂ + **2**H₂O + **1**NO Balancing the number of H:

- **b** + 1 = 4 **b** = 3
- ⇒C
- 5 To calculate the relative molecular mass, which is the average mass of <u>one molecule</u>

of the compound, relative to $\frac{1}{12}$ the mass

of ¹²C, the *molecular formula* which shows the <u>actual number</u> of each atom is needed and not the empirical formula which shows the simplest ratio.

Since the <u>average mass</u> of one molecule of the compound is required, the *relative atomic* masses of the elements in the compound, which is averaged over the isotopic distribution, is needed and not the exact relative isotopic masses. 6 X is a 3s orbital and Y is a 3p orbital. For the *same* principal quantum shell, energy of the orbitals: ns < np < nd < nfThere are 1 *ns* orbital and 3 *n*p orbitals for each principal quantum number $n \ge 2$. \Rightarrow **A**

7 1
$$\checkmark$$
: $A_{\rm r} = \frac{60.1 \times 69 + 39.9 \times 71}{100} \approx 69.8$

- 2 ✓: The atomic number of Ga is 31, hence both isotopes have 31 protons.
- 3 ✓: ⁶⁹Ga has 69 nucleons (neutrons + protons), while ⁷¹Ga has 71.
- \Rightarrow A
- 8 $2\checkmark$ 8 pairs of e⁻s are shared



9 $pH = -lg [H^+] = 1.4$ $\left[H^+\right] = 10^{-1.4} = 0.0398 \text{ mol } dm^{-3}$

$$n_{\rm H^{+}} = 0.0398 \times 4 = 0.159 \text{ mol}$$

 $H_2 X \rightarrow 2 {\rm H}^+ + X^{2-}$
 $n_{\rm H_2 X} = \frac{1}{2} n_{\rm H^{+}} = 0.0796 \text{ mol}$
 $\Rightarrow {\bf B}$

10 Halogen exists as non-polar diatomic X₂ molecules held together by instantaneous dipole-induced dipole attractions.

Volatility, *i.e.* boiling, involves overcoming the intermolecular forces of attraction and **not** breaking of the X–X bond.

Instantaneous dipole-induced dipole attractions get stronger from F_2 to I_2 due to the increasingly number of electrons in the X_2 molecules and hence higher polarisability of the electron cloud.

 $\Rightarrow \textbf{C}$

- A ✓: Both Al₂O₃ and SiO₂ are insoluble in water, hence the pH are both 7.
 - B ★: Na₂O reacts exothermically with water to give NaOH.
 - C ★: Both Al₂O₃ and SiO₂ are insoluble in water, hence no reaction.
 - D *: Only Na₂O is fully soluble in water to give a clear solution of NaOH. MgO is only sparingly soluble, while Al₂O₃ and SiO₂ are insoluble in water, resulting in a clear solution with *undissolved* solid.

 \Rightarrow A

- **12** ¹¹⁴F*l* is in Group 14, with 4 valence electrons. Hence, F*l* is able to loss all 4 valence electrons to give the F*l*⁴⁺ cation, with the highest oxidation state of +4. Thus, the formula of the oxide is $Fl^{4+}(O^{2-})_2$.
 - \Rightarrow D

13 1 √: Group 13, with 3 valence electrons
 2 ★: Element has electronic configuration of 1s²2s²2p⁶3s²3p³ ⇒ Group 15

3 *****: $1s^22s^1 \Rightarrow$ Group 1

4 ✓: Element has electronic configuration of $1s^22s^22p^63s^23p^1 \Rightarrow$ Group 13

⇒B

- 14 A *: KOH should be soluble like NaOH.
 - B ✓: Al reacts with Cl₂ to give solid AlCl₃.
 Ga should react similarly.
 - **C ***: GeO₂ should have a giant molecular structure, similar to SiO₂.
 - D ★: AsCl₃ should have a simple molecular structure like PCl₃.

 \Rightarrow B

- **15** A *****: Oxidation state of H is +1, S is -2. H₂ is oxidised to H₂S.
 - B ✓: Contains the H⁻ ion where the oxidation state of H is −1. H₂ is reduced to H⁻.

 - D ★: Oxidation state of H is +1, P is −3. H₂ is oxidised to PH₃.
 - \Rightarrow B

16
$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$CH_4 + \frac{3}{2}O_2 \rightarrow CO + 2H_2O$$

Adding up.

$$2CH_4 + \frac{7}{2}O_2 \rightarrow CO + CO_2 + 4H_2O$$

$$n_{CH_4} = \frac{1.0}{12.0 + 1.0 \times 4} = 0.0625 \text{ mol}$$

$$n_{O_2} = \frac{7}{2} \times \frac{0.0625}{2} = 0.1094 \text{ mol}$$

$$V_{O_2} = 0.1094 \times 24 = 2.63 \text{ dm}^3$$

$$\Rightarrow \mathbf{B}$$

17 $\Delta H_{\rm f}^{\ominus}$ (methanol):

$$C + 2H_2 + \frac{1}{2}O_2 \rightarrow CH_3OH$$
------(1)

$$\Delta H_{\rm f}^{\oplus}(\rm CO)$$
:

$$C + \frac{1}{2}O_2 \rightarrow CO - (2)$$

 $\Delta H_{c}^{\ominus}(\text{ethanol})$:

$$\begin{split} C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O & \ensuremath{\cdots} \ensuremath{\cdot} (3) \\ \Delta H^\oplus_c \left(CO \right) \ensuremath{:} \end{split}$$

$$\mathrm{CO} + \frac{1}{2}\mathrm{O}_2 \to \mathrm{CO}_2 - \dots + (4)$$

$$\Delta H_{t}^{\oplus} (\mathsf{CO}) = \Delta H_{t}^{\oplus} (\mathsf{CO}) + \Delta H_{c}^{\oplus} (\mathsf{CO})$$

$$\Rightarrow$$
 A

18 |L.E.| $\propto \left| \frac{q_+ \times q_-}{r_+ + r_-} \right|$

[L.E.] is greater for $M^{2+}X^{2-}$ (Group 2 and Group 16) than $M^{+}X^{-}$ (Group 1 and Group 17)

|L.E.| is greater when r_{-} is smaller (top of Group 16)

- 19 A ✓: Lattice energy is the energy released when one mole of a solid ionic lattice is formed from its constituent gaseous ions.
 - **B ***: The ions should be in the gaseous state.
 - **C ***: One mole of FeC $l_3(s)$ instead of two and not formed from the elements.
 - **D ***: Opposite of lattice energy of Na₂O.

⇒А

20 Since X remains unchanged and it speeds up the rate of reaction, X is a catalyst.

Catalyst increases the rate of reaction by providing an alternate pathway with lower activation energy.

Activation energy is the difference between the energy of reactants and the highest point in the energy profile diagram.

- ⇒C
- 21 1 *: The average energy (kinetic energy) of the molecules depends only on the temperature, which is constant in this case.
 - 2 *: The Boltzmann distribution depends on the mass of the particles and the temperature, which are both constant in this case.
 - 3 ✓: A catalyst, e.g. enzyme, speeds up a reaction by providing an alternative pathway with lower activation energy. $\Rightarrow \mathbf{D}$

22 $k = \frac{\text{rate}}{[N_2O_5]} = \frac{0.00276 \text{ mol } \text{dm}^{-3} \text{ s}^{-1}}{0.040 \text{ mol } \text{dm}^{-3}}$ $= 0.0690 \text{ s}^{-1}$

Since the $[N_2O_5]$ is halved after every 10 s, the half-life of the reaction is 10 s. \Rightarrow C

23 From expt 1 and 2, when [Z] is doubled, the rate is doubled, hence first order w.r.t. Z. From expt 1 and 3, when [X] is doubled, the rate is doubled, hence first order w.r.t. X. From expt 3 and 4, when [Y] is doubled, the rate remains constant, hence zero order w.r.t. Y.

Thus, rate = $k[X]^{1}[Y]^{0}[Z]^{1} = k[X][Z]$ \Rightarrow D

24
$$K_c = \frac{[\text{NOBr}]^2}{[\text{NO}]^2 [\text{Br}_2]} = \frac{0.0049^2}{0.12^2 \times 0.13}$$

= 0.0128 mol⁻¹ dm³
 \Rightarrow C
25 H CN H CN H CN H CN

Since poly(ethene) is non-polar, the most likely type of bonding between a polymer of methyl cyanoacrylate and poly(ethene) is instantaneous dipole-induced dipole attractions.

 \Rightarrow C

26 Thermoplastics has low melting points and becomes mouldable at a certain elevated temperature and solidifies upon cooling. Hence, they can be recycled.

Thernosets generally do not melt when heated, but typically decompose at high temperature and do not reform upon cooling. Hence, they cannot be recycled.

Thermosets are generally stronger than thermoplastics due to the 3-dimensional network of bonds (crosslinking) and keep their shape as strong covalent bonds between polymer chains cannot be broken easily.

 $\Rightarrow \mathbf{A}$ 27 CH₃ $H_3C-\dot{C}-CH_3$ ÒН $3 \text{ R groups} \Rightarrow 3^{\circ}$ propanoate ethyl \Rightarrow D **28** A ✓: C₅H₈O₃ **B** ✓: C₅H₈O₃ **C** ✓: C₅H₈O₃ D *: C₅H₁₀O₃ $\Rightarrow \mathbf{D}$ **29** $1 \checkmark$: $\begin{array}{c} (H - Br) \\ H - C - C - H \\ H \\ H \end{array} \rightarrow \begin{array}{c} H - Br \\ H - C - C - H \\ H \\ H \end{array} \rightarrow \begin{array}{c} H - Br \\ H - C - C - H \\ H \\ H \\ H \end{array}$ H ρ

2 ★:
$$H - C - C' \xrightarrow{\times} cannot undergoes$$

 $H + H$ elimination
3 ✓: $H - C - C - H \xrightarrow{} H - C = C - H$
 $H + H + H + H$
 $\Rightarrow B$

30 R-CH₂OH \longrightarrow R-CO₂H Each $-CH_2OH \rightarrow -CO_2H$, -2H and +1O

Four $-CH_2OH \Rightarrow -8H$ and +4OHence, $C_5H_{12}O_4 \rightarrow C_5H_4O_8$ $\Rightarrow A$

Answer Key

Qn Ans

11

12

13

14

15

16

17

18

19

20

А

D

в В

В

В

А

D

А

С

Qn	Ans
1	А
2	А
3	D
4	С
5	С
6	А
7	А
8	А
9	В
10	С

Qn	Ans
21	D
22	С
23	D
24	С
25	С
26	А
27	D
28	D
29	В
30	А