Secondary 3 (IP) EOY Answers

2021 Sec 3 End-of-Year Exam Chemistry Answers

Paper 1

1	**B**	2	**C**	3	**A**	4	**C**	5	**B**
6	**B**	7	**D**	8	**D**	9	**C**	10	**D**
11	**A**	12	**C**	13	**A**	14	**C**	15	**A**
16	**B**	17	**C**	18	**B**	19	**A**	20	**B**
21	**B**	22	**D**	23	**A**	24	**A**	25	**A**
26	**A**	27	**B**	28	**C**	29	**A**	30	**B**

Qn	Ans	Explanation
1	B	At –46°C, M is a solid. At 110°C, M is a gas. Melting and boiling points of M must both be between –46°C and 110°C.
2	C	For the water level at X to decrease, the rate of diffusion of gas P into the porous pot must be faster than the rate of diffusion of air out of the porous pot. Hence, gas P needs to have a lower M_r than air (< 28.96). The rate of diffusion of gas Q into the porous pot must be slower than the rate of diffusion of air out of the porous pot. Hence, gas Q needs to have a higher M_r than air (> 28.96). For option B, both carbon monoxide and nitrogen have the same M_r. Hence, there will be no change in the level of **X**.
3	A	The independent variable is the one that is changed. This is the volume of acid used. A burette is used because the volume of acid that can be measured can vary but not when a pipette is used because the volume measured is fixed. The dependent variable is the one that is measured. This is the temperature recorded and hence, a thermometer is used.
4	C	A is not possible as sulfur dioxide is highly soluble in water. B is wrong because sulfur dioxide is more densed than air and downward delivery should be used. D is wrong because the acidic gas of sulfur dioxide will react with concentrated potassium hydroxide, which is an alkali.
5	B	Apparatus is a separating funnel that separates immiscible liquids (eg. oil and water). The bottom layer would have a higher density and would be collected first when the tap is opened. Since organic solvents like carbon disulfide and water are immiscible, they can be separated using the separating funnel.
6	B	The R_f value of the sample as shown in Y is 0.5. Hence, the spot should appear at the 0.5 mark in a longer piece of paper.

7	D	B and C are wrong because the number of protons should follow the proton numbers. A is wrong because an ion with 2+ charge should have 2 more protons than electrons.
8	D	If X has 7 valence electrons (group 17), Y would have 8 valence electrons (group 18) and Z would have 1 valence electron (group 1). From statement 2, we can identify X and Y as period 3 elements chlorine, C*l*, and argon, Ar. Z is potassium, K. A is false as X^- ion and Z^+ ion would form a compound ZX. B is false as relative atomic mass of Y (Ar) is 39.9 while that of Z (K) is 39.1. C is false as the next electron should be found in the 4s subshell. The 3d subshells are not filled. D is true as Z is a metal and X is a non-metal.
9	C	Ar of potassium = 39(93.258/100) + 40(0.012/100) + 41(6.730/100) = 39.13
10	D	H^{2-} ion would have 3 electrons and the spdf notation would be $1s^2\ 2s^1$, which does not follow the electronic configuration of any of the noble gases. H^- ion is a possible ion that has an spdf notation of $1s^2$.
11	A	There are no negative values for options B, C and D.
12	C	Calcium hydroxide reacts with ammonium nitrate to form calcium nitrate, ammonia and water. Nitrogen is lost through ammonia gas being released to the surroundings.
13	A	chemical equation: $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$ ionic equation: ~~$2Na^+(aq)$~~ + $CO_3^{2-}(aq) + 2H^+(aq)$ + ~~$2Cl^-(aq)$~~ → ~~$2Na^+(aq)$~~ + ~~$2Cl^-(aq)$~~ + $CO_2(g) + H_2O(l)$
14	C	The difference between the two test tubes is the solvent that is used. With water being used as a solvent in tube B, only tube B shows effervescence, indicating that the citric acid is able to react with magnesium in an acid + metal reaction. This shows citric acid only produces hydrogen ions when dissolved in water, showing its acidic properties.

15	A	no. of mol of HX required = 0.100 mol dm^{-3} x 0.020 dm^3 = 0.002 mol Hence, A is incorrect. HX is a strong acid as the final pH is about 1. Concentration of NaOH = 0.002 mol / 0.025 dm^3 = 0.08 mol dm^{-3}
16	B	Candidates are expected to know : • metallic oxides are basic • non-metallic oxides are acidic in nature • aluminium oxide is amphoteric • carbon monoxide is neutral Hence, to neutralize NaOH, only Al_2O_3 , P_4O_{10} and CO_2 are able to display acidic properties.
17	C	The common uses of SO_2 are in the use of the manufacture of bleaching agents and food preservatives. Noble gases are used in the manufacture of low energy light bulbs.
18	B	$PbCl_2$ is an insoluble salt and should be prepared via precipitation method – mixing of two aqueous solution containing Pb^{2+} and Cl^- . Hence, it is important to first prepare a solution containing aqueous Pb^{2+}. Option B is the only correct answer because : Adding lead to *excess* nitric acid will ensure that all the solid lead will completely react and dissolve to produce aqueous $Pb(NO_3)_2$. Subsequently, $Pb(NO_3)_2$ (aq) is added to dilute HCl to produce solid $PbCl_2$ which can be easily collected as residue via filtration. Option C is wrong as excess lead is added but not removed which will affect the purity of the $PbCl_2$ collected.
19	A	Statement 1 is correct. A lower pH signifies a higher concentration of H^+. Statement 2 is correct. pH = - log $[H^+]$ Statement 3 is incorrect. pH 5 is weakly acidic. Hence it should be orange / yellow. Statement 4 is correct. For example, the ionic equation for the reaction between hydrochloric acid and sodium metal: $2H^+(aq) + Na(s) \rightarrow Na^+(aq) + H_2(g)$ It is evident that the oxidation state of Na increases from 0 to +1 in Na^+. Hence it lose electrons and is thus oxidized.

<table>
<tr><td>20</td><td>B</td><td>Assuming all the solutions have a concentration of 1 mol dm^{-3} and exist in a volume of 1 dm^3.

Option A: 1 mol of $(NH_4)_2SO_4$ = 3 mol of ions (2 x NH_4^+ + 1 x SO_4^{2-})

Option B: 1 mol of $Al(NO_3)_3$ = 4 mol of ions (1 x Al^{3+} + 3 x NO_3^-)

Option C: 1 mol of $Fe(NO_3)_2$ = 3 mol of ions (1 x Fe^{2+} + 2 x NO_3^-)

Option D: 1 mol of NaCl = 2 mol of ions (1 x Na^+ + 1 x Cl^-)</td></tr>
<tr><td>21</td><td>B</td><td>Percentage by mass = $\frac{\text{No. of element x Ar of element}}{\text{Mr of compound}}$ x 100%
<table><tr><th>Element</th><th>No. of element</th><th>Total Mass Contributed</th></tr><tr><td>C</td><td>5</td><td>5 x 12.0 = 60.0</td></tr><tr><td>Cl</td><td>2</td><td>2 x 35.5 = 71.0</td></tr><tr><td>H</td><td>11</td><td>11 x 1.0 = 11.0</td></tr><tr><td>N</td><td>1</td><td>1 x 14.0 = 14.0</td></tr></table>Hence, the element with highest percentage by mass is Chlorine.</td></tr>
<tr><td>22</td><td>D</td><td>Mass of O_3 permitted in 1 cm^3 of air = 8 x 10^{-9} g

Amount of O_3 = 8 x 10^{-9} / 48

No. of molecules of O_3 = 8 x 10^{-9} x L / 48</td></tr>
<tr><td>23</td><td>A</td><td>Amount of gas produced per day = 480 / 24 = 20 mol
Since CO_2 : CH_4 = 1:1,
Amount of CO_2 = Amount of CH_4 = 10 mol</td></tr>
<tr><td>24</td><td>A</td><td>Since the reaction vessel is enclosed, there is no net gain or loss of reactants and products (By law of conservation of mass) , hence statement 1 is correct.
By mole ratio
CH_4 : O_2 : CO_2
1 : 2 : 1
Volume ratio 50 : 100 : 50
Hence, the volume of oxygen required to react with 50 cm^3 of methane is 100 cm^3 and there are 50 cm^3 of O_2 that is unreacted and in excess. Hence, at the end of the reaction the total volume of gas comprise of O_2 (unreacted) + CO_2 produced: 50 + 50 = 100 cm^3.

The 50 cm^3 of CO_2 produced is acidic and will be absorbed by aqueous potassium hydroxide, which is an alkaline.</td></tr>
</table>

25	A	SO_2 is a pungent and acidic gas. It is able to decolourise acidic potassium manganate.
26	A	Green solution and green precipitate upon the addition of aqueous ammonia is characteristic of the Fe^{2+} ion. Fe^{2+} can be easily oxidized to Fe^{3+} which the reddish brown precipitate ($Fe(OH)_3$). Nitric acid is added to test for carbonate anion which is not present as no effervescence is observed. Hence, the yellow precipitate formed upon the addition of silver nitrate is due to the presence of I^-
27	B	Statement 3 is incorrect. Across the period, atomic radius decreases. This is so as nuclear charge increases as number of protons increases. Shielding effect is similar as number of electron shells stays the same. There is greater electrostatic forces of attraction between protons in the nucleus and the valence electrons and hence atomic size decreases.
28	C	Option A is incorrect. Group 1 metals forms **ionic bonds** with the halogens. Option B is incorrect. Group 1 metals reacts with water to form metallic oxides, which are bases. The halogens **do not react** with water. Statement D is incorrect. The melting point increases down the group.
29	A	Reactivity of group 17 halogens decreases down the group. A halogen higher up in the group can displace a halide ion lower in the group.
30	B	The key information provided in the question are: (i) all the elements have increasing proton numbers. (ii) may not be next to each other in the periodic table (iii) Q is chemically inert. This suggest that element Q is a noble gas and is the last element of the period. As such, R will be in *a different period from both P and Q.* *Q being a noble gas* only has *weak intermolecular forces of attraction* between its atoms. P is a *group 1 metal* since it is able to react readily with water to form an alkaline solution.

Paper 2

A1	Answers	Marks
(a)(i)	**Boiling [1**]	[3]
	Heat energy (is absorbed by molecules/particles) **to overcome the forces of attraction between particles/molecules. [1]** Since **no change in (average) kinetic energy [1]** temperature remains constant.	
(a)(ii)	At point A, the molecules/particles (will not penalized here if students use ions or atoms) are: **closely packed/regular arrangement [1]** and **vibrate about fixed position**. **[1]**	[2]
(b)	Boiling point **increases down the group** 17 halogens**. [1]**	[3]
	as **number of electrons increases/M_r increases/molecular size increases/electron cloud size increases** from Cl_2 to Br_2 to I_2. **[1]** **More energy** required to *overcome stronger intermolecular forces.* **[1]**	
	Total	**[8]**

A2	Answers	Marks
(a)	**Na^+: 2.8**	[1]
	K^+ : 2.8.8	
(b)(i)	Down the group, • The atomic radii **increases down Group 1. [1]** • **number of electron shells increases [1]**	[3]
	• **valence electrons** are **further away** from the positive **nucleus [1]**	
(b)(ii)	• the **ionic radius** of Li **is smaller** than the atomic radius. / **Li^+** has a **smaller radius** than **Li**/the **radius decreases [1]** • Reason: As Li loses 1 electron to form Li^+, Li has **one electron shell fewer than Li^+ [1] / Electrostatic forces of attraction between the nucleus and the remaining electrons increases / electron cloud size is smaller [1]**	[2]
(c)(i)	• **$2 Li + 2H_2O \rightarrow 2LiOH + H_2$ [1]** • **Not marking for state symbols.**	[1]
(c)(ii)	Describe: Down the group, as **atomic radius increases from 152pm for lithium to 227 pm** for potassium **[1]** , **the reactivity of the group 1 elements increases [1]** [1] – For the use of data [1] – For relationship	**[2]**
	Total	**[9]**

<table>
<tr><th>A3</th><th>Answers</th><th>Marks</th></tr>
<tr><td>(a)</td><td>Mass of Al = 100 – 53.3 – 1.7
= 45.0g [1]</td><td>[1]</td></tr>
<tr><td>(b)(i)</td><td>
<table>
<tr><td></td><td>A/</td><td>O</td><td>H</td></tr>
<tr><td>mass ratio</td><td>45.0</td><td>53.3</td><td>1.7</td></tr>
<tr><td>mole ratio</td><td>$\frac{45.0}{27.0}$
= 1.6666</td><td>$\frac{53.3}{16.0}$
= 3.3312</td><td>$\frac{1.7}{1.0}$
= 1.70</td></tr>
<tr><td>simplest whole number ratio</td><td>$\frac{1.6666}{1.6666}$
= 1.00</td><td>$\frac{3.3312}{1.6666}$
= 1.9987</td><td>$\frac{1.70}{1.6666}$
= 1.0200</td></tr>
<tr><td></td><td>1</td><td>2</td><td>1</td></tr>
</table>
Hence, the empirical formula of boehmite is A/O_2H.
Students are reminded to show their working and leave answers in intermediate steps to 4 or 5 sf.
Calculations are important in this question as it is a proving question.</td><td>[2]</td></tr>
<tr><td>b(ii)</td><td>Balanced equation:
A/$^{3+}$ (aq) + 3OH$^-$ (aq) → A/O_2H (s) + H_2O (l)</td><td>[2]</td></tr>
<tr><td>(c)</td><td>Test: Add aqueous ammonia <u>in excess</u> [1]

Al^{3+} (aq) : will produce a white precipitate insoluble <u>in excess</u>. [1]

Zn^{2+}(aq) : will produce a white precipitate <u>soluble in excess</u> to form a colourless solution. [1]</td><td>[3]</td></tr>
<tr><td>(d)</td><td>2 [Al]$^{3+}$ 3[]$^{2-}$</td><td>[2]</td></tr>
<tr><td></td><td>Total</td><td>[10]</td></tr>
</table>

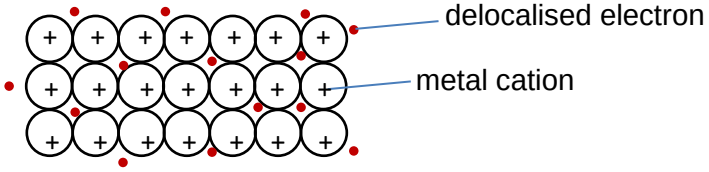
A4	Answers	Marks
(a)	$No.of\ moles\ of\ MnO_4^- = \frac{22.50}{1000} \times 0.0200$ **= 4.50 × 10^{-4} mol**	[1]
(b)	No. of moles of H_2O_2 (25.0 cm^3 of FA2) = $4.50 \times 10^{-4} \times \frac{5}{2}$ = $1.125 \times 10^{-3}\ mol$ **= 1.13 x 10^{-3} mol**	[1]
(c)	No. of moles of H_2O_2 (500 cm^3 of FA2) = $1.125 \times 10^{-3} \times \frac{500}{25}$ = $\mathbf{2.25 \times 10^{-2}\ mol}$	[1]
(d)	No. of moles of H_2O_2 (500 cm^3 of FA2) = No. of moles of H_2O_2 (12.5 cm^3 of FA1) = $2.25 \times 10^{-2}\ mol$ Concentration of H_2O_2 (FA1) = $2.25 \times 10^{-2} \times \frac{1000}{12.5}$ **= $\mathbf{1.80\ mol\ dm^{-3}}$**	[1]
	Total	**[4]**

A5	Answers	Marks
(a)(i)	gas **V** : ammonia / NH_3 **[1]** Separation technique **W: Filtration [1]** Solid **X** : $Cu(OH)_2$ / Copper (II) hydroxide **[1]**	[3]
(a)(ii)	Light blue precipitate **dissolves** to give a **dark blue solution.**	[1]
(a)(iii)	NH_4^+ , Cu^{2+} / ammonium ion, copper (II) ions	[2]
(b)(i)	To eliminate the presence of **carbonate / hydroxide** ions. (either one) [1]	[1]
(b)(ii)	NO_3^- , Cl^- **[2]**	[2]
	Total	**[9]**

B6	Answers	Marks
(a)(i)	average = (22.70 + 22.80)/2 = 22.75 cm^3 (2 d.p.) no. of mol of KOH = 0.250 mol dm^{-3} x (22.75/1000) dm^3 = 0.0056875 = 0.00569 mol (3 sf)	 [A1]
(a)(ii)	KOH + HC*l* → KC*l* + H_2O Since KOH:HC*l* = 1:1 By mole ratio, no. of mol of HC*l* = 0.0056875 mol concentration of HC*l* = 0.0056875 mol **÷ (25/1000) dm^3** = 0.2275 mol dm^{-3} = 0.228 mol dm^{-3} (3 s.f.)	 [M1] [M1]
(a)(iii)	no. of mol of original HC*l* = 18/36.5 = 0.49315 mol no. of mol of HC*l* reacted = **0.49315 – 0.2275** = 0.26565 mol = 0.266 mol (3 s.f.)	 [A1] [M1]
(a)(iv)	Since HC*l*:A*l*$_2O_3$ = 6:1 By mole ratio, no. of mol of A*l*$_2O_3$ = 0.26565 **÷ 6** = 0.044275 mol mass of A*l*$_2O_3$ = 0.044275 mol **x ([2(27)+3(16)]** g mol^{-1} = 4.51605 g % purity of A*l*$_2O_3$ = (4.51605**/5) x 100%** = 90.3% (3 s.f.)	 [M1] [M1] [M1]
(a)(v)	The impurities in aluminium oxide do not react with acid/HCl/base/alkali/KOH/both HCl and KOH.	[1]
(b)	Aluminium forms a covalent bond with chlorine instead of an ionic bond. OR Aluminium does not have a stable octet configuration. / only has 6 electrons in its outermost shell.	Any [1] mark
	Total	**[10]**

B7	Answers	Marks
(a)(i)	An acid that produces <u>2 hydrogen ions</u> for <u>a molecule of the acid</u>.	[1]
(a)(ii)	$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$	[1]
(a)(iii)	Strong acids like H_2SO_4 have higher K_a values; due to the presence of high concentration of H^+ ions; OR Weak acids like H_2CO_3 have lower K_a values; due to the presence of low concentration of H^+ ions;	[1] [1] [1] [1]
(a)(iv)	$$\mathbf{K_a = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}}$$	[1]
(a)(v)	$$\mathbf{K_a = \frac{[H^+][HCO_3^-]}{[H_2CO_3]} = \frac{[H^+](0.750)}{(1.50)}}$$ $$\mathbf{[H^+] = 2K_a = 2 \times 4.3 \times 10^{-7} = 8.6 \times 10^{-7}\ mol\ dm^{-3}}$$	 [1]
(b)(i)	$H_2CO_3 + Ba(OH)_2 \rightarrow BaCO_3 + 2H_2O$	[1]
(b)(ii)	precipitate / solid seen	[1]
(b)(iii)	thymolphthalein **Endpoint 2 (or pH 10.3)** falls within the **gradual colour change** range (of 9.3 – 10.5).	[1] [1]
	Total	**[10]**

B8 EITHER	Answers	Marks
(a)(i)	Period 3	[1]
(a)(ii)	Gallium (31 electrons) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^1$	 [1]
(b)	Across the period, nuclear charge increases **and/or** number of protons increases shielding effect is similar **and/or** number of electron shells stays the same there is a greater electrostatic forces of attraction between protons in the nucleus and the **valence** electrons atomic radii decreases.	 [1] [1] [1] [1]
(c)	Silicon has a giant molecular/covalent structure; Larger amount of energy needed to overcome strong covalent bonds between silicon **atoms**. Chlorine has a simple molecular/covalent structure; Smaller amount of energy needed to overcome weak intermolecular forces (between its molecules).	[1] [1] [1] [1]
	Total	**[10]**

B8 OR	Answers	Marks
(a)(i)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$	[1]
(a)(ii)	 Strong electrostatic forces of attraction between metallic cations and 'sea' of delocalised electrons.	well-labelled diagram [1] [1]
(a)(iii)	high melting point; high density; variable oxidation states; form coloured compounds; malleable/ductile; good conductor of heat;	[1]
(a)(iv)	catalyst; catalyses / speed up the rate of reaction	[1]
(b)	Potassium loses 1 valence electron to form potassium ion. Calcium loses 2 valence electrons to form calcium ion. **OR** Potassium has 1 valence electron / Calcium has 2 valence electrons. **OR** Potassium has 1 less valence electron than calcium. Calcium contributes **more** delocalised / free-moving / mobile electrons per atom and has higher electrical conductivity.	 [1] [1]
(c)	**Each** carbon atom uses 3 out of 4 of its valence electrons for bonding / forms bonds with 3 other carbon atoms. **Covalent** bonds / giant **covalent/molecular** structure / **shares** electrons one valence electron (not used in bonding) that is delocalised / free-moving / mobile and is able to conduct electricity.	[1] [1] [1]
	Total	**[10]**