2024 SIP Chemistry Prelim Key

Paper 1

1	2	3	4	5	6	7	8	9	10
D	A	D	C	C	D	B	A	D	C
11	12	13	14	15	16	17	18	19	20
A	B	C	A	B	B	A	B	C	A
21	22	23	24	25	26	27	28	29	30
D	A	D	C	D	A	A	B	C	B
31	32	33	34	35	36	37	38	39	40
D	D	B	A	B	D	C	A	C	B

Explanation

No	Ans	Explanation
1	D	When T decreases, particles have less KE and move more slowly from one another.
2	A	Ethylamine has lower M_r of 45 as compared to hydrogen chloride with M_r of 36.5 and diffuses at a slower rate. Hence the white solid will be formed at A.
3	D	Oxygen is an element, glucose $C_6H_{12}O_6$ is a compound (fixed composition) and air (which has variable composition of components from which it's made up) is a mixture.
4	C	copper(II) sulfate and water can be separated by simple distillation(to obtain water) or crystallization (to obtain copper(II) sulfate); methanol and ethanol are separated by fractional distillation due to their different bp; methanol and ethanol can be separated by fractional distillation due to their different bp; sand and silver chloride cannot be separated by filtration as both are insoluble in water.
5	C	The molecules that can be obtained are $C_2H_3{}^{35}Cl_3$, $C_2H_3{}^{37}Cl_3$, $C_2H_3{}^{35}Cl_2{}^{37}Cl$, $C_2H_3{}^{35}Cl{}^{37}Cl_2$
6	D	Magnesium reacts with dilute hydrochloric acid to form magnesium chloride (ionic compound) and hydrogen (molecules of element). Magnesium atom transfer 2 electrons, one to each chlorine atom.
7	B	Particles that enable electrical conductivity are free, mobile ions and delocalised electrons. Copper is able to conduct electricity due it its 'sea' of delocalised electrons while graphite can conduct electricity as there is one valence electron per carbon atom that is not involved in bonding.
8	A	The total number of electrons in the compound includes those which are not in the valence shells. Each bond in the diagram represents a pair of electrons.
9	D	Zinc ions produces a white precipitate in both aq sodium hydroxide and ammonia which dissolves in excess.
10	C	Only silver ions will form a white precipitate with chloride ions.
11	A	Percentage composition of N in N_2O = (14x2)/(14x2+16) x 100% = 63.6% Percentage composition of O in N_2O = (16)/(14x2+16) x 100% = 36.4%

<table>
<tr><td>12</td><td>B</td><td>No. of moles of calcium nitrate = 13.3/(40+2x14+6x16) = 0.08110
By comparing mole ratio, no. of moles of calcium oxide = 0.08110
mass of calcium oxide present = 0.081 x (40+16) = 4.54 g
Percentage purity = 4.54/7 x 100% = 65.0%</td></tr>
<tr><td>13</td><td>C</td><td><table>
<tr><td></td><td>C_3H_8 +</td><td>$5O_2 \rightarrow$</td><td>$3CO_2$ +</td><td>$4H_2O$</td></tr>
<tr><td>Initial</td><td>60</td><td>100</td><td></td><td></td></tr>
<tr><td>Used</td><td>20</td><td>100</td><td></td><td></td></tr>
<tr><td>Left / produced</td><td>40</td><td>0</td><td>60</td><td>80 (but it will cool to a liquid)</td></tr>
</table>
Total volume of gas = 40 + 60 = 100 cm^3</td></tr>
<tr><td>14</td><td>A</td><td>Products of electrolysis: lead (grey) and bromine (reddish – brown)
Reaction at cathode: Pb^{2+} reduced by gaining 2 e^- to form Pb.
Reaction at anode: Br^- oxidised by losing 2 e^- to form Br_2.</td></tr>
<tr><td>15</td><td>B</td><td>Magnesium and silver are the furthest from each other in the electrochemical series and hence, produces the highest voltage.</td></tr>
<tr><td>16</td><td>B</td><td>For concentrated potassium chloride,
Hydrogen ions gets reduced to form hydrogen gas at the cathode (potassium will not be discharged) while chloride ions (due to its high concentration) gets oxidised to form chlorine gas.
The potassium and hydroxide ions will form potassium hydroxide which has a pH of more than 7, resulting in an increase in the pH of the electrolyte.</td></tr>
<tr><td>17</td><td>A</td><td>At the copper anode, copper, which loses electrons more readily than the anions present, will undergo oxidation to form copper(II) ions.</td></tr>
<tr><td>18</td><td>B</td><td>As the energy level of the products is higher than that of the reactants, this is an endothermic reaction. The activation energy, which is the minimum energy particles must possess before a reaction can proceed, can be found by subtracting R from P.</td></tr>
<tr><td>19</td><td>C</td><td>Statement 1: The activation energy, Ea, is the minimum energy the colliding particles must have in order to react.
The other 2 statements are true as thermal energy is taken in during an endothermic reaction and this leads to a decrease in T of the surrounding. Bonding making is an exothermic process as energy is given out.</td></tr>
<tr><td>20</td><td>A</td><td>Increasing the pressure and temperature in the vessel increases the rate of reaction involving gases.</td></tr>
<tr><td>21</td><td>D</td><td>Neutralisation is exothermic in nature and the enthalpy change is negative.</td></tr>
<tr><td>22</td><td>A</td><td>Method 1 measures the volume of carbon dioxide gas collected through the displacement of water, method 2 measures the mass loss due to loss of carbon dioxide. There’s no measurement in a physical quantity in method 3 that allows the rate of reaction to be measured.</td></tr>
<tr><td>23</td><td>D</td><td>Statements 3 and 4 confirm the acidic nature of dilute sulfuric acid as acids have pH less than 7 and react with copper(II) oxide.</td></tr>
<tr><td>24</td><td>C</td><td>Non-metal oxides are usually acidic in nature. Carbon reacts with oxygen to form carbon dioxide which is acidic.</td></tr>
<tr><td>25</td><td>D</td><td>The indicators turn yellow in solutions with pH more than 5. Only Z has pH more than 5.</td></tr>
<tr><td>26</td><td>A</td><td>Copper(II) nitrate is a soluble salt which can be prepared by reacting excess base / carbonate with acid.</td></tr>
</table>

27	A	Iron has been oxidised to form iron(II) while hydrogen in sulfuric acid has been reduced to form hydrogen gas.
28	B	The melting point of halogens increases as molecular size increases.
29	C	The group number in the Periodic Table is determined by the number of valence electrons while the period number is determined by the number of occupied shells. The elements are arranged according to increasing proton number.
30	B	The charge on the silver ion is 1+. Silver ions undergo reduction to form silver, Ag while magnesium undergo oxidation to form Mg^{2+}.
31	D	In rust prevention, zinc forms a barrier between iron and the oxygen and water in the atmosphere. When a layer of zinc is scratched, it gets oxidised before iron does. When iron rusts, atoms of iron loses electrons to form ions.
32	D	Oxygen which is formed during photosynthesis does not have an effect on global warming.
33	B	A reduction in livestock farming reduces the production of methane and reduces the effect of climate change. Using low-sulfur fuel reduces the amount of sulfur dioxide which contributes to acid rain.
34	A	Finely divided iron is used as catalyst in the Haber process. The addition of hydrogen to alkene produces alkane.
35	B	Sugar cane is a renewable resource. Sugar cane undergoes photosynthesis in which carbon dioxide is utilised.
36	D	Since there is only one carbon-carbon double bond in both molecules, they react with equal masses of bromine.
37	C	Ethane reacts with chlorine in a step-wise substitution reaction in which the hydrogen atom in ethane is progressively replaced by a chlorine atom.
38	A	Equation for combustion of hexan-3-ol: $C_6H_{13}OH + \mathbf{9}O_2 \rightarrow 6CO_2 + 7H_2O$
39	C	Methyl propanoate can be formed from methanol and propanoic acid. The C−O must be found in methanol while the C=O must be found in the acid.
40	B	The repeat unit of X is $–[CH(CH_3)CH(CH_3)]–$ while Y must be a polyester as it is formed between a dicarboxylic acid and a diol.

Paper 2

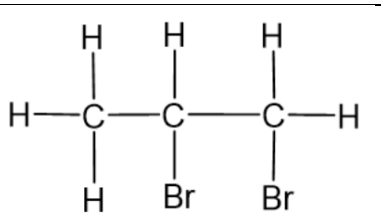
<table>
<tr><td>1</td><td>(a)(i)</td><td>CO</td><td>1</td></tr>
<tr><td></td><td>(ii)</td><td>Al_2O_3 / PbO</td><td>1</td></tr>
<tr><td></td><td>(iii)</td><td>CO / CO_2 / SO_2 / H_2O</td><td>1</td></tr>
<tr><td></td><td>(iv)</td><td>CaO / PbO</td><td>1</td></tr>
<tr><td></td><td>(v)</td><td>CO_2 / CaO / Na_2O / SO_2</td><td>1</td></tr>
<tr><td></td><td>(vi)</td><td>CO_2</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>• fractional distillation
• boiling points of both glucose and ethanol are different.</td><td>1
1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>(a)</td><td><table><tr><td>particle</td><td>number of particles</td></tr><tr><td>electron</td><td>18</td></tr><tr><td>neutron</td><td>16</td></tr><tr><td>proton</td><td>15</td></tr></table></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>P <u>needs 3 electrons</u> to fulfill the noble gas configuration / octet structure.</td><td>1</td></tr>
<tr><td></td><td>(c)(i)</td><td>Yes. It is an ionic compound with
<u>giant crystal / ionic lattice structure</u> and <u>strong electrostatic forces of attraction between oppositely charged ions.</u>
<u>A lot of energy is required</u> to overcome the strong electrostatic forces of attraction hence, calcium phosphate is expected to have high melting point.</td><td>
1

1</td></tr>
<tr><td></td><td>(ii)</td><td>Percentage by mass of phosphorus = 2x31/(3x40+2x31+8x16) x 100%
= 20.0%</td><td>
1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>(a)</td><td>$3MoO_2 + 4Al \rightarrow 2Al_2O_3 + 3Mo$</td><td>1</td></tr>
<tr><td></td><td>(b)(i)</td><td><table><tr><th>element</th><th>oxidation state in reactants</th><th>oxidation state in products</th></tr><tr><td>molybdenum</td><td>+4</td><td>0</td></tr><tr><td>aluminium</td><td>0</td><td>+3</td></tr></table></td><td>

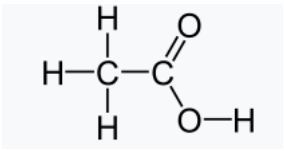
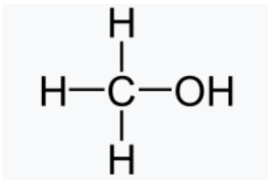
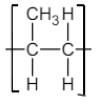
1

1</td></tr>
<tr><td></td><td>(ii)</td><td>Molybdenum(IV) oxide has been reduced as the oxidation state of molybdenum has decreased from +4 in MoO_2 to 0 in Mo.
Aluminium has been oxidised as the oxidation state has increased from 0 in Al to +3 in Al_2O_3.
Since oxidation and reduction occur simultaneously, this is a redox reaction.</td><td>
1

1</td></tr>
</table>

	(c)	Molybdenum is <u>less reactive</u> as <u>it has been displaced</u> from its oxide / molybdenum(IV) oxide has been reduced by alumnium	1
	(d)(i)	Metallic bonding. Structure drawn to show cations in a 'sea' of delocalized electrons.	1 1
	(ii)	<u>Stronger electrostatic forces of attraction</u> due to higher number of electrons and protons present in Mo.	1
4	**(a)(i)**	iron(III) chloride	1
	(ii)	$Cl_2(g) + 2Br^- \rightarrow Br_2(aq) + 2Cl^-(aq)$ **T** is bromine.	1 1
	(iii)		1
	(b)(i)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ $2Cl^-(aq) \rightarrow Cl_2(aq) + 2e^-$	1 1
	(ii)	Moist blue litmus paper turns red then bleached	1
	(iii)	Both <u>hydrogen and chloride ions are discharged from the solution</u>, leaving behind sodium and hydroxide ions.	1
	(iv)	To prevent mixing of the products from the 2 electrodes.	1
	(v)	Steel contains iron which will react with chlorine to form iron(II) chloride. Graphite / any inert electrode	1 1
5	**(a)**	$2NiO + C \rightarrow 2Ni + CO_2$ produces <u>carbon dioxide gas</u> which is <u>a greenhouse gas</u> that contributes to global warming. This leads to the melting of polar ice caps and flooding of low-lying areas / decrease in crop yield / unusual weather conditions / release of carbon dioxide dissolved in oceans which further adds to greenhouse effect	1 1 1
	(b)	Student B is correct as: Ni^{2+} ions are present in the electrolyte and will get preferentially discharged at the cathode to form Ni. The positions of the electrodes are incorrect as: • impure nickel should be connected to the positive terminal of the battery so that it can undergo • oxidation to form Ni^{2+} • pure nickel should be connected to the negative terminal of the battery so that Ni^{2+}can undergo • reduction to form Ni	 1 1 1 1 1
	(c)	Nickel is <u>less reactive than iron</u> and <u>loses electrons less readily</u> Hence, it cannot protect the pipe which is made of iron from rusting.	1 1
6	**(a)**	The enthalpy change / ΔH value is negative so it is an exothermic	1

		reaction.	
	(b)(i)	ΔH_1 = +941 kJ (breaking of N≡N) ΔH_2 = 3(+436) = +1308 kJ (breaking of H−H) ΔH_4 = -92 kJ ΔH_3 = -(+941 +1308) + (- 92) = -2341 kJ Bond energy of N−H = 2341/6 ≈ 390 kJ/mol	1 1 1 1 1
	(ii)	E_a = 941 + 1308 ≈ 2250 kJ/mol	 1
7	**(a)**	• reacts quickly with water / lithium dissolves in water • lithium darts about in water • effervescence / bubbles produced 1 mark for 1 observation	2
	(b)	• the <u>rate of reaction decreases</u> as the amount of lithium present decreases • eventually stops as there is <u>no more lithium present</u>.	1 1
	(c)	9.5s	1
	(d)(i)	Experiment 2: 56.3 cm^3 Experiment 3: 225 cm^3	1 1
	(ii)	Experiment 2: Rate of reaction will be <u>slower</u> as <u>amount of lithium is less resulting in fewer effective collisions per unit time.</u> Experiment 3: Rate of reaction will be <u>faster</u> as <u>particles possess more KE / more particles possess energy equal to or greater than E_a resulting in more effective collisions per unit time.</u>	 1 1 1 1
8	**(a)**	SO_2 contributes to the formation of acid rain which lowers the pH of soil/water bodies and corrodes structures and buildings made of limestone and metal.	1 1
	(b)	Fossil fuels / petroleum	1
	(c)	<u>Nitrogen from air reacts with oxygen</u> at high temperatures to produce oxides of nitrogen.	1
	(d)	<u>Carbon dioxide</u>	1
	(e)	Wet scrubbers: Advantage: low operating cost Disadvantage: produces carbon dioxide which is a greenhouse gas Copper oxide technology: Advantage: reduces both oxides of sulfur and nitrogen / does not produce landfill waste / does not produce carbon dioxide	 1 1

		Disadvantage: requires the use of a lot of natural resources (308.4g/kgS as compared to 2.1g/kgS for wetscrubbers) 1 mark for each advantage/ disadvantage	1 1
9	**(a)**	They have the • Same general formula of $C_nH_{2n+2}COO$ where n is ≥2 • Same functional group of COO • M_r between successive members differ by 14 / molecular formula between successive members differ by a $-CH_2$ Any 1 for 1 mark.	2
	(b)	The melting point increases then decreases (no clear trend) but the boiling point increases as the molecular size / M_r increases	1 1
	(c)	The melting point is below 25 °C and the boiling point is above 25 °C OR 25 °C is between its melting and boiling point.	1 1
	(d)(i)	 organic acid  compound **Y** 1 mark for each correct drawing	2
	(ii)	No. of moles of acid = 1.20 g / 60 = 0.02 mol No. of moles of methyl ethanoate = 0.02 mol Mass of methyl ethanoate = 0.02 x 74 = 1.48 g	1 1
10	**(a)(i)**	 n	1
	(ii)	• $2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$ • No. of moles of propene = (4.2x1000)/42 = 100 mol Volume of carbon dioxide produced = 3 x 100 x 24 = 7200 dm^3 Percentage yield = 4800/7200 x 100% = 66.7 % ECF allowed for incorrectly balanced equation.	 1 1
	(b)(i)	• Both have the molecular formula C_3H_6 but • the arrangement of atoms is different (candidate needs to explain	1

		the difference fully in their own words)	
	(ii)	• reagent: Br_2 (aq) • reddish brown bromine decolourises when added to propene but remains unchanged when added to cyclopropane	1 1
	(c)(i)	• movement: from vibrate about fixed position to move throughout the liquid • arrangement: from very close, orderly arrangement to close but disorderly arrangement	 1 1
	(ii)	• SiO_2 has a giant molecular structure and strong covalent bonds between atoms. • A lot of energy is needed to overcome the bonds hence it has a high melting point.	1 1