Secondary 3 (IP) EOY Answers

2018 Sec 3 End-of-Year Exam Chemistry Answers

Paper 1

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

Explanations for Paper 1

MCQ	Explanations
1	Substance B has boiling point between 0 to 25 °C None of the other substances has melting or boiling points between 0 to 25 °C
2	During melting, heat energy supplied (option A is not true) is used to overcome attractive forces between particles B: Particles will have kinetic energy at all temperatures except for 0 K C: No chemical reaction is occurring
3	Separating funnel: used to separate 2 or more immiscible liquids A: aqueous solution of NH_4Cl and $Pb(NO_3)_2$ present B: aqueous KI will form immiscible layer with $CHCl_3$ C: aqueous solution of $NaNO_3$ and KNO_3 present D: insoluble solid + liquid present
4	When cooled to room temperature, since lead(II) sulfate is insoluble at room temperature, it will crystallise → crystals can be separated from the mixture by filtration, obtaining crystals as residue
5	Since gas is collected by upward delivery → gas must be less dense than air → average M_r of gas must be less than average M_r of air (28.9) → gas must be H_2
6	Best choice of indicators will be 1 indicator which changes colour just below pH of 4.5 (methyl orange), and 1 indicator which changes just above pH of 4.7 (methyl red)
7	A strong acid ionises completely in water to form H^+ ions and anions
8	Ionic equations for reactions: (1) $2H^+(aq) + MgO(s) \rightarrow Mg^{2+}(aq) + H_2O(l)$ (2) $2H^+(aq) + 2K(s) \rightarrow 2K^+(aq) + H_2(g)$ (3) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ Since H^+ ions are not involved in reaction 3, H_2SO_4 is not behaving as an acid

<table>
<tr><td>9</td><td>Titration: used to prepare soluble group 1 and ammonium salts → only options A and D

Precipitation: used to prepare insoluble salts → only options A, B and D

Adding excess solid reactants: used to prepare soluble salts that are not group 1 or ammonium salts → only options B, C and D

Only option D is correct for all 3 methods</td></tr>
<tr><td>10</td><td>Since metallic oxides are already expected to be basic, an equation showing that the metallic oxide is also acidic (ie a reaction with base/alkali) will show that metallic oxide is amphoteric → option B shows the metal oxide reacting with OH^-

C: Reaction of metal oxide with H^+ just confirms the fact that it is basic</td></tr>
<tr><td>11</td><td>From topic of QA, $Pb(OH)_2$ is insoluble in excess aqueous ammonia, while $Cu(OH)_2$ is soluble in excess aqueous ammonia to form dark blue solution

Therefore $Pb(OH)_2$ can be obtained by adding aqueous ammonia and filtering

D: $Cu(OH)_2$ will be obtained instead of $Pb(OH)_2$</td></tr>
<tr><td>12</td><td>Test with KI: Pb^{2+} present

Test with aqueous NaOH, Al: NO_3^- present (Note that NH_4^+ could also be present but answer cannot be option D as SO_4^{2-} cannot be present since R is a colourless solution)</td></tr>
<tr><td>13</td><td>Same observations if NH_3(aq) or NaOH(aq) added

Different observations if H_2SO_4(aq): white precipitate formed if Pb^{2+} is present, no observable change if Al^{3+} is present

No observable change if $Ba(NO_3)_2$(aq) is added</td></tr>
<tr><td>14</td><td><table>
<tr><th></th><th>KNO_3</th><th>K_2CO_3</th></tr>
<tr><td>Aqueous NH_3</td><td>No observable change</td><td>No observable change</td></tr>
<tr><td>Aqueous $AgNO_3$</td><td>No observable change</td><td>Yellow precipitate formed (colour of this precipitate is not required in syllabus)</td></tr>
<tr><td>Aqueous HCl</td><td>No observable change</td><td>Effervescence of colourless odourless gas</td></tr>
</table></td></tr>
<tr><td>15</td><td>Since there are $3Mg^{2+}$ and $2OH^-$, $[Si_4O_{10}]$ has to have a charge of 4– for the sum of the charges to be 0</td></tr>
<tr><td>16</td><td>A: molar mass of D_2O = 2 + 2 + 16 = 20

B: Since H_2O turns anhydrous copper(II) sulfate blue, D_2O will have the same property (isotopes have similar chemical properties so the compounds they form should also have similar chemical properties)

C: Since H_2O is a liquid, D_2O should also be a liquid since the strength of their intermolecular forces will be similar

D: H_2O has a bent shape, so D_2O also has a bent shape</td></tr>
</table>

17	Ion of X has 36 electrons and charge of 2+ → X has 38 protons Isotopes contain same number of protons (either options C or D), but different number of neutrons (only option D)
18	B: Carbon nanotube has a giant covalent structure so it is not expected to be soluble in water C: Only 3 out of 4 valence electrons of each carbon atom are used for covalent bonding, so carbon nanotube has mobile delocalised electrons to conduct electricity (similarity to graphite) D: Carbon nanotube has a giant covalent structure so it is expected to have high melting point By elimination, option A is only possible answer
19	A: True since electrostatic forces of attraction can act over long distances, just that the attraction will be weaker for ions that are further away B: Sharing of valence electrons is how covalent bonds are formed C: Cannot be true since option A is true D: $NaCl$ forms a giant ionic structure, not a molecule
20	A: I_2 contains covalent bonds between I atoms, and intermolecular forces between B: Since both I atoms have same electronegativity, I_2 is non-polar C: Down the group, ionisation energy decreases as valence electrons are further away from the nucleus so they experience weaker electrostatic forces of attraction to the nucleus → 1st IE of iodine is lower than bromine D: I can gain electron to form I^-
21	Moles of C atoms = 0.400 x 6 = 2.40 mol Number of C atoms = 2.40 x 6.02×10^{23} = 1.44×10^{23} (3sf)
22	Moles of $HClO_4$ = $\frac{50}{1000}$ x 2.5 = 0.125 mol Moles of H^+ = 0.125 mol $[H^+]$ = 0.125 ÷ $\frac{500}{1000}$ = 0.250 mol dm^{-3}
23	(1) molecular formula = $C_2H_4O_2$, empirical formula = CH_2O (2) molecular formula = $C_4H_8O_2$, empirical formula = C_2H_4O (3) molecular formula = $C_4H_8O_2$, empirical formula = C_2H_4O
24	Moles of CaCO3 = 50.1 ÷ 100.1 = 0.50050 mol Moles of CaO = 0.50050 mol Theoretical mass of CaO = 0.50050 x 56.1 = 28.078 g % yield of CaO = $\frac{5.61}{28.078}$ x 100% = 20.0% (3sf)

25	% by mass of C in $C_3O_2 = \frac{12.0 \times 3}{68.0} \times 100\% = 52.9\%$ % by mass of C in CO = $\frac{12.0}{28.0} \times 100\% = 42.9\%$ % by mass of C in $CO_2 = \frac{12.0}{44.0} \times 100\% = 27.3\%$
26	Moles of CO_2 = 66.0 ÷ 44.0 = 1.50 mol Moles of H_2O = 36.0 ÷ 18.0 = 2.00 mol Moles of CO_2:H_2O = 1.50:2.00 = 3:4 Moles of C:H = 3:8
27	$H_2SO_4(aq) + CuO(s) \rightarrow CuSO_4(aq) + H_2O(l)$ Since none of the reactants are gases, pressure of surrounding air will not affect the reaction
28	Since adding substance X (catalyst) decreases the activation energy, it will cause the rate of reaction to increase
29	(1) False. The decrease in rate of reaction is faster initially, as concentration of reactants decreases faster initially (due to faster rate of reaction) (2) True. For an effective collision to occur, molecules must collide in correct orientation and with energy equal to or greater than E_a (3) False. Fast reactions generally have lower E_a (4) True. Rate is fastest at the start as concentration of reactants is the highest
30	Reaction 2 has lower rate and higher yield Effect of changes on reaction: A: lower rate, same yield B: lower rate (as added H_2O_2 has lower concentration), higher yield (more moles of H_2O_2 in solution) C: lower rate, same yield D: different rate, same yield

Paper 2

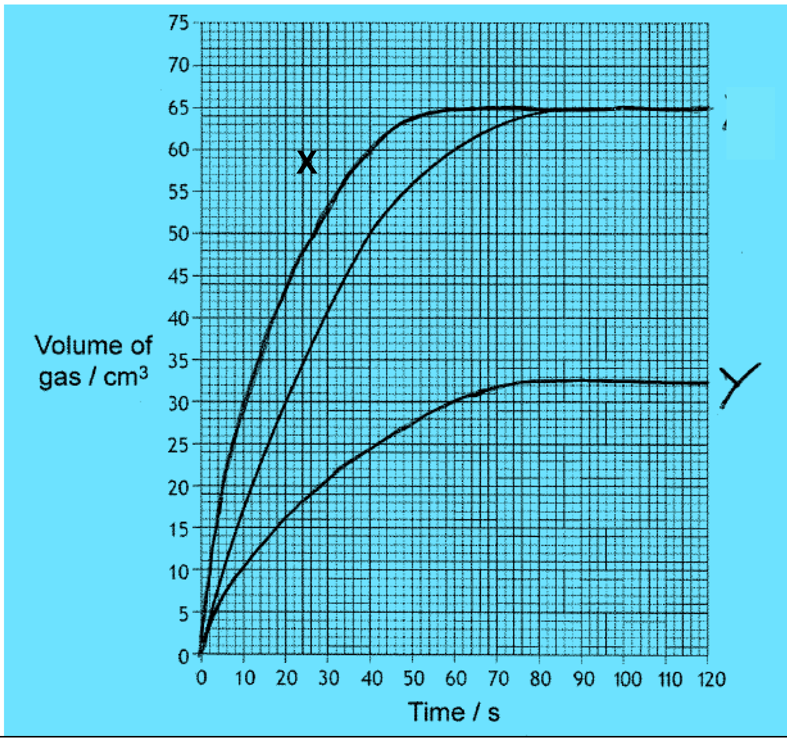
Question	Answers	Marks
A1		
(a)	Number of sigma-bonds = seven / 7. Number of pi-bonds = one / 1. [1] for both correct answers. Do not award half-marks.	**[1]**
(b)(i)	Tetrahedral [1].	**[1]**
(b)(ii)	Four bonding pairs of electrons and zero / no non-bonding or lone pairs of electrons [1].	**[1]**
(c)	Both aqueous ethanoic acid and sodium ethanoate contain mobile ions [1]. Accept mobile charge carrying particles. Do not accept mobile electrons.	**[1]**
(d)	There are relatively weak London dispersion forces (between –	**[2]**

Question	Answers	Marks
	CH_3) or relatively weak hydrogen bonds (between –OH) between the molecules of ethanoic acid [1], but strong electrostatic forces of attraction between the oppositely charged ions of sodium ethanoate [1].	
(e)(i)	Titration [1].	[1]
(e)(ii)	Add calcium carbonate to ethanoic acid while warming and stirring [1]. Add until there is excess / unreacted calcium carbonate in the beaker [1]. Filter the mixture, the calcium ethanoate is the filtrate [1]. Three marking points to a maximum of two marks.	[2]
(e)(iii)	Solubility of calcium ethanoate decreases with increasing temperature [1]. OR Solubility of calcium ethanoate increases with decreasing temperature [1]. Crystals will not form as the saturated solution cools [1]. Therefore, solid calcium ethanoate should be obtained by heating / evaporating to dryness [1].	[3]
	Total	[12]

A2					
(a)	**A** = $ZnCO_3$ / zinc carbonate	[1]	**B** = $(NH_4)_2SO_4$ / ammonium sulfate	[1]	[7]
	C = CO_2 / carbon dioxide	[1]	**D** = $Zn(NO_3)_2$ / zinc nitrate	[1]	
	E = $Zn(OH)_2$ / zinc hydroxide	[1]	**F** = NH_3 / ammonia	[1]	
	G = $BaSO_4$ / barium sulfate	[1]			
(b)	Gas **F** is alkaline./ Gas F forms OH^- with water.				[1]
(c)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ [1] Equation must include state symbols.				[1]
	Total				[9]

A3		
(a)	number of moles of $Na_2CO_3 = 1.60 \times 45.0 \times 10^{-3} = 0.0720$ number of moles of $AgNO_3 = 2.00 \times 40.0 \times 10^{-3} = 0.0800$ [1] mark for both the number of moles of Na_2CO_3 and $AgNO_3$ number of moles of Na_2CO_3 required $= 0.0800 \div 2 = 0.0400$ [1] $\therefore$ 0.0720 mol of Na_2CO_3 is excess, hence $AgNO_3$ is limiting [1] OR number of moles of $AgNO_3$ required $= 0.0720 \times 2 = 0.144$ $\therefore$ 0.0800 mol of $AgNO_3$ is limiting [1]	[3]
(b)	number of moles of $AgNO_3 = 0.0800$ $\therefore$ number of moles of $Ag_2CO_3 = {}^1/_2 \times 0.0800 = 0.0400$ [1] mass of $Ag_2CO_3 = 0.0400 \times 275.8 = 11.032$ g = 11.0 g (3 s.f.) [1] Note: There is an error carried forward from (a) to (b)	[2]
(c)	mass of Ag_2CO_3 used $= 11.032 \div 4 = 2.758$ g [1] number of moles of Ag_2CO_3 used $= 2.758 \div 275.8 = 0.0100$ [1] 0.0100 mol of Ag_2CO_3 produce ${}^3/_1 \times 0.0100$ mol of gas $= 0.0300$	[4]

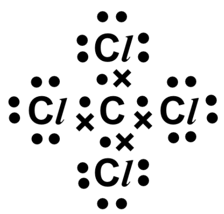
	mol [1] total volume of gas = 0.0300 × 24 000 = 720 cm^3 [1] Note: There is an error carried forward from (b) to (c)	
(d)	The relative molecular mass of hydrogen (M_r = 2) is lower than the relative molecular mass of carbon dioxide (M_r = 44) [1]. Hydrogen gas diffuses into the porous pot faster than carbon dioxide gas diffuse out of the porous pot [1]. Pressure inside the porous pot increases, pushing the level of the water at point **Z** down [1].	**[3]**
	Total	**[12]**

A4		
(a)	A catalyst increase the rate of reaction by providing an alternative pathway of lower activation energy. Reject: lowers activation energy	**[1]**
(b)	The concentration of hydrogen peroxide decreases / no. of hydrogen peroxide per unit volume decreases as it is consumed during the reaction [1]. Frequency of effective collisions decreases, causing the rate to decrease [1]. Marks not given for second pt when first point is not related to concentration or number of hydrogen peroixde molecules.	**[2]**
(c)(i) **(c)(ii)**	Steeper gradient, to the left of the original graph. Final volume = 65 cm^3 [1]. Shallower gradient, to the right of the original graph. Final volume = 32.5 cm^3 [1]. No labels = 0 marks 	**[2]**
(d)(i)	Iodide ions take part / participate in the reaction, but are not consumed by the reaction / are regenerated / renewed during the reaction [1].	**[1]**
(d)(ii)	Iodide ions will be removed from aqueous solution /silver iodide precipitates [1].	**[1]**

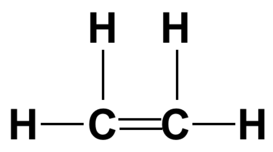
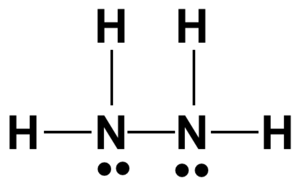
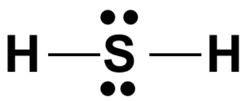
	Reject: Iodine ions react with silver nitrate	
	Total	**[7]**

B5		
(a)	Comparing experiments 1 and 3 with the initial concentration of oxygen remaining constant at 0.0300 mol dm^{-3} [1], the tripling of the initial concentration of nitrogen monoxide resulted in about nine-fold increase in the rate of formation of nitrogen dioxide ($7.56 \times 10^{-1} / 8.52 \times 10^{-2} = 8.87$) [1]. Accept answers that compares the experiment numbers or by stating that the initial concentration of oxygen remains unchanged.	**[2]**
(b)	Comparing experiments 1 and 2 with the initial concentration of nitrogen monoxide remaining constant at 0.0200 mol dm^{-3} [1], the tripling of the initial concentration of oxygen resulted in a tripling in the initial rate of formation of nitrogen dioxide ($2.56 \times 10^{-1} / 8.52 \times 10^{-2} = 3$) [1]. Accept answers that compares the experiment numbers or by stating that the initial concentration of nitrogen monoxide remains unchanged.	**[2]**
(c)(i)	The reaction is second order with respect to the change in concentration of nitrogen monoxide [1].	**[1]**
(c)(ii)	The reaction is first order with respect to the change in concentration of oxygen [1].	**[1]**
(d)(i)	From the equation, volume ratio of nitrogen monoxide to oxygen is 2 : 1. Volume ratio of nitrogen monoxide to oxygen reacted = 25.0 : 30.0 = 1.00 : 1.20 = 2.00 : 2.40 [1] Therefore, the limiting reactant is nitrogen monoxide [1]. Alternatively, From the equation, volume ratio of nitrogen monoxide to oxygen is 2 : 1. Volume of oxygen required = $0.5 \times 25 = 12.5$ cm^3 Since the volume of oxygen required is more than than the 30 cm^3 of oxygen used, oxygen is added in excess and nitrogen monoxide is the limiting reactant. Alternatively, From the equation, mole ratio of nitrogen monoxide to oxygen is 2 : 1. No. of moles of nitrogen monoxide = 25/24000 = 0.0010417 (5 s.f.) No. of moles of oxygen = 30/24000 = 0.0012500 (5 s.f.)	**[2]**

	No. of moles of oxygen required = 0.0010417 × 0.5 = 0.00052085 (5 s.f.) Since the number of moles of oxygen required is less than the number of moles of oxygen added, it is in excess and nitrogen monoxide is the limiting reactant. Accept other alternative methods that show that nitrogen monoxide is the limiting reactant.	
(d)(ii)	Volume of nitrogen monoxide reacted = 25.0 cm^3 From the equation, volume ratio of nitrogen monoxide to nitrogen dioxide = 2 : 2 Volume of nitrogen dioxide formed = 25.0 cm^3 [1] Practise ECF if answer to part (bi) is incorrect.	**[1]**
	Total	**[9]**
B6		
(a)(i)	Volume of pure methanoic acid in one fire ant $= 8.25 \times 10^{-6} \times 60/100$ $= 4.95 \times 10^{-6}$ dm^3 [1] No. of ants needed $= (1.50/1000)/\ 4.95 \times 10^{-6}$ = 303 (nearest integer) [1] Reject no. of ants needed as 304 as question specifically ask to round off the answer to the nearest integer	**[2]**
(a)(ii)	Volume of methanoic acid injected in one ant bite $= 8.25 \times 10^{-6} \times 65/100$ $= 5.3625 \times 10^{-6}$ dm^3 [1] Volume of methanoic acid in one ant sting $= 5.3625 \times 10^{-6} \times 60/100$ $= 3.2175 \times 10^{-6}$ dm^3 $= 3.22 \times 10^{-6}$ dm^3 / 3.22×10^{-3} cm^3 / 0.00322 cm^3 (3 s.f.) [1]	**[2]**
(b)(i)	A weak acid is a substance, which ionises partially to form hydrogen ions in solution. Reject if students state that all organic acids are weak as they are expected to explain what is a weak acid without reference to methanoic acid. Reject if students only mention partial ionisation without mentioning the formation of hydrogen ions (in water)	**[1]**
(b)(ii)	Effervescence is observed [1]. A colourless and odourless gas is evolved [1] which forms a white precipitate in limewater [1]. 1 mark for either describing effervescence or the colour and odour of the gas, 1 mark for describing the formation of white precipitate in limewater.	**[2]**
(b)(iii)	$HCOOH + NaHCO_3 \rightarrow HCOONa + CO_2 + H_2O$	**[1]**

	Accept NaHCOO for formula of the salt.	
(b)(iv)	No. of moles of methanoic acid injected = 6.30×10^{-3}/ $(1.0 \times 2 + 12.0 + 16.0 \times 2)$ = 1.3696×10^{-4} [1] From the equation, 1 mol of HCOOH reacts with 1 mol of $NaHCO_3$ No. of moles of $NaHCO_3$ = 1.3696×10^{-4} [1] Volume of $NaHCO_3$ = 1.3696×10^{-4}/ 0.100 = 0.00137 dm^3 or 1.37 cm^3 [1] Practise ECF if equation from **(bi)** is incorrect.	**[3]**
	Total	**[11]**
EITHER B7		
(a)(i)		**[1]**
(a)(ii)	Tetrachloromethane has a simple molecular/ covalent structure.	**[1]**
(a)(iii)	Tetrachloromethane has a tetrahedral molecular shape.	**[1]**
(b)(i)	Accept any values of boiling points of lead(IV) chloride from 138 to 151 °C.	**[1]**
(b)(ii)	The boiling points of the chlorides increase moving from the chlorides of silicon to germanium to tin [1]. For $SiCl_4$ to $GeCl_4$ to $SnCl_4$, as the number of electrons increases/ size of electron clouds increases/ electron clouds become more polarisable [1], the strength of the (London) dispersion forces/ instantaneous dipole-induced dipole forces between the molecules increases [1] which requires greater thermal energy to overcome.	**[3]**
(c)(i)	$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$	**[1]**
(c)(ii)	Tetrachloromethane will not react with water [1] as carbon with an electronic configuration of $1s^22s^22p^2$ does not have d-orbitals just like silicon to accept lone pairs from water molecules [1]. To explain why tetrachloromethane does not react with water, students must either indicate the spdf notation of carbon or draw the orbital diagram of carbon to conclude that there is an absence of d-orbitals.	**[2]**
	Total	**[10]**

OR B7

(a)(i)	  1 mark for each correct Lewis structure	**[2]**
(a)(ii)	The molecular shape for ethene is trigonal planar [1] and that for hydrazine is trigonal pyramidal [1]. Do not accept if students state the molecular shape of hydrazine as pyramidal only.	**[2]**
(b)	Ethene has lower melting and boiling points than that of hydrazine [1]. Ethene is a non-polar molecule while hydrazine is a polar molecule. Hydrogen bonds are present between the hydrazine molecules [1] which are significantly stronger than the London dispersion/ instantaneous dipole-induced dipole forces between the ethene molecules [1]. Students need to identify the correct intermolecular forces between hydrazine and ethene molecules and to state that hydrogen bonds is stronger than London dispersion/ instantaneous dipole-induced dipole forces.	**[3]**
(c)	Ammonia has 4 electron pairs.	**[1]**
(d)(i)		**[1]**
(d)(ii)	The molecular shape of hydrogen sulfide is angular/ bent/ v-shaped. Do not accept non-linear for the molecular shape of hydrogen sulfide.	**[1]**
	Total	**[10]**