2016 Sec 3 End-of-Year Exam Chemistry Answers

Paper 1

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

Paper 2

Section A

No	Answers	Marks
A1(a)	A: any carbonates except for silver carbonate and lead(II) carbonate B: any <u>ammonium salt</u> Common mistake: Writing chemical name instead of formula	[1] [1]
A1(b)	Effervescence stops OR no more bubbles produced Common mistakes: Writing that effervescence forms; testing for carbon dioxide	[1]
A1(c)	Mr of CO_2 = 12 + 16 +16 = 44 Mr of NH_3 = 14 + 1 +1 + 1 = 17 Ammonia gas diffuses faster (reaches mosquitoes faster) as it has a lower molecular mass. Common mistakes: Wrong terminology; wrong units	 [1] [1]
		[Total: 5]
A2(a)	The melting point increases from Na_2O to MgO and decreases from MgO to SO_2. Common mistakes: Trend not clearly spelt out; pointing out individual values instead of outlining a trend; describing increase in mp to Gp III instead of II	[1]
A2(b) (i)	In SiO_2, Si and O atoms are held together by **<u>strong covalent bonds</u>** in **<u>giant molecular structure</u>**. In P_4O_6, the molecules are held together by **<u>weak intermolecular forces of attraction</u>** in a **<u>simple molecular structure</u>**. Hence, SiO_2 has a higher melting point than P_4O_6. Structure and bonding for each molecule must be mentioned to	[1] [1]

No	Answers	Marks
	obtain 1 full mark each. If only structure is mentioned for both molecules, award 1 mark only. If only bonding is mentioned for both molecules, award 1 mark only. Common mistakes: Being unclear what constitutes "bonding" and what constitutes "structure"; describing silicon dioxide as ionic	
A2(b)(ii)	Both NaC*l* and MgCl_2 are held together by **strong ionic bonds** in a **giant lattice structure**. Hence, they have similar melting point. Common mistake: Omitting description of structure	[1]
A2(c)	Any specifically stated value lower than (but not including) -73^{o}C but greater than -200 ^{o}C (can use M_r of other compounds to estimate how low the mp will be) Common mistake: Not stating a specific value, but instead stating "low" or "lower than -73 ^{o}C"; no units	[1]
		[Total: 5]
A3(a)(i)	$Ca_3(PO_4)_2$ (s) + 6HNO_3 (aq) → 3$Ca(NO_3)_2$ (aq) + 2H_3PO_4 (*aq*) No marks if either Balanced equation or State symbols are incorrect/ missing or wrong formula	[1]
A3(a)(ii)	Phosphoric acid is a weak acid, which partially dissociates in water. Nitric acid is a strong acid, which fully dissociates in water. OR [1m] Strength of acid [1m] Dissociation of acid Accept: Nitric acid is a stronger acid than phosphoric acid [1] as it dissociates/ionises more completely/fully than phosphoric acid in water [1] if student wrote either "both acids are strong as they completely dissociate in water" or "both are weak as they partially dissociate in water" → 1 m only Reject: - One of them is stronger as it dissociates completely in water	[1] [1]

No	Answers	Marks
	- Nitric acid dissociates more in water than phosphoric acid - Nitric acid deionized in water	
A3(b)(i)	No. of moles of $Ca(NO_3)_2$ = 246 000 000 / 164 = 1 500 000 mol Molar mass of NH_4NO_3 = (14 x 2) + 4 + (16 x 3) = 80 g mol^{-1} Mass of NH_4NO_3 produced = 1 500 000 x 2 x 80 = 240 000 000 g = 240 tonnes	[1] [1] [1]
A3(b)(ii)	% yield = (181/240) x 100 = 75.4 % (to 3 s.f.) [allow ecf]	[1]
	[Total: 7]	
A4(a)	Step 1: To react/neutralise with excess/unreacted Mg/MgO To remove/ dissolve Mg/MgO (BOD) Reject: - if they stated the product as MgC*l* (wrong formula, but common mistake) - If they said that the purpose was to produce $MgCl_2$ or water with no additional explanations (accept if they continue to elaborate that it was to produce a soluble salt from an insoluble base, MgO) - To remove B or B_2O_3 Step 2: To react with (excess/unreacted) hydrochloric acid in step 1 To remove excess acid (BOD) Reject: - to react with MgO (no such reaction) - B_2O_3 as it was the limiting reagent, so should not have any left - $MgCl_2$ with NaOH	[1] [1]

No	Answers	Marks
	Step 3: To remove any impurities such as unreacted NaOH, $MgCl_2$, NaCl Accept: - To remove any solid/aqueous impurities - To remove/wash off any contaminants/unwanted residues/ excess solutions Reject: - To remove liquid impurities(no liquids produced except water) - To remove chemicals (B can be considered a chemical as well - vague)	[1]
A4b	Melt the boron and check if it melts/boils at a fixed temperature. Accept: - Check if it melts over a range of temperatures - Check if the melting / boiling point is the same as that of pure boron / is below the melting point of pure boron/ boiling point above pure boron Reject: - Heat the sample. - Calculate the percentage purity of the sample - Calculate the theoretical yield based on number of moles of reactants and the actual yield from the mass of B obtained, then find percentage purity - Chromatography - React the sample with an acid/ alkali - Filteration/ Dry the residue with filter paper - Crystallisation Comments: Boiling boron should not be the correct method to determine the purity of boron, as it was given from the equation that boron is a solid at room temperature → melting point should be used. In general, most students confused percentage purity with percentage yield based on their description. Note that percentage yield is only based on the mass of the product obtained and the theoretical mass, but does not tell you anything about the purity of the sample. Chromatography was rejected as it is unlikely to find a solvent to dissolve	[1]

No	Answers	Marks
	boron in.	
A4c	No. of moles of Boron extracted = 22 000 / 11 = 2000 mol [1] No. of moles of Mg used in reaction = 2000 x 3/2 = 3000 mol [1] Mass of Mg used in reaction = 3000 x 24 = 72000 g or 72kg [1] Accept any answer more than 72 kg since Magnesium is in excess.	[3]
		[Total: 14]
A5(a)	A: Lead (II) carbonate [1] B: carbon dioxide [1] C: Lead (II) oxide [1] D: Lead (II) nitrate [1] E: Lead (II) hydroxide [1] F: calcium carbonate [1] Reject answers in chemical formulae.	[6]
A5(b)	The white precipitate dissolves to give a colourless solution	[1]
A5(c)	calcium oxide and carbon dioxide Reject answers in chemical formulae.	[1]
		[Total: 8]
A6(a)	Size and shape of particles will affect **surface area of solids** which will affects the rate of reaction and hence affects the temp. rise / vol. of CO_2 evolved after 4 minutes interval. Keeping $MgCO_3$ of the same size and shape will ensure that the surface area of solids **remain constant** for the various experiments for a **fair comparison**.	[1] [1]
A6(b)	The higher the concentration of the hydrochloric acid, the faster the reaction rate/ more CO_2 evolved / greater rise in temperature.	[1]
A6(c)	**More reactant particles per unit volume** increases the frequency of collisions between the reactant particles.	[1]

No	Answers	Marks
	Reject: • Acid molecules are referred to as reactant particles. • Per unit volume not mentioned. • Per unit area/ space This in turns increases the frequency of effective collisions which increase the rate of reaction.	[1]
A6(d)(i)	Both HCl and HNO_3 are **monobasic acids**. No. of moles of H+ ions produced by the two acids is the same/ same concentration of H+ ions Reject: • Only same concentration of acid is mentioned without basicity. • Both are strong acids hence concentration of H^+ is the same.	[1] [1]
A6(d)(ii)	0.30°C	[1]
		[Total:8]

Section B

B7			
	(a) (i)	Isotopes are atoms of the same element with the **same number of protons/atomic number/proton number** but **different number of neutrons [1]**.	[1]
	(a)(ii)	Deduct 1m for every wrong figure in the table. Deduct 1m if answers not presented in tabular format.	[3]

	^{39}K	^{40}K	^{41}K
number of protons	19	19	19
number of electrons	19	19	19
number of neutrons	20	21	22

	(b)	1. Heat the mixture in evaporating dish to sublime ammonium chloride. 2. Add water to the remaining mixture and stir till all of potassium chloride has dissolved. 3. Filter the mixture to obtain filtrate, KCl solution. 4. Evaporate KCl solution to dryness to obtain dry KCl salt. OR 4. Heat the solution until saturated. Leave the solution to cool until crystals are formed. Filter off the excess solution to obtain the crystals of KC*l* as the residue. Dry between two pieces of filter paper (no marks awarded for this step, crystallisation, if any part is missing). Award 1m for each correct step. Comments: A common misconception is that ammonium chloride can sublime even when it is dissolved in water. Crystallisation is not a good method to obtain KC*l* crystals, as KC*l* is very soluble in even cold water, hence the yield of the crystals (which is dependent on the difference in solubilities at different temperatures) will be very bad. Another common mistake is to wash the crystals with distilled water after obtaining pure KC*l*. As KC*l* is very soluble, washing it with even cold distilled water will cause the few crystals that you have to dissolve. Hence, this step can be ommitted and just dry the crystals with filter paper. A small number of students misinterpreted the question as one of how to prepare KC*l* salt, ignoring the table of information and context given.	[4]
	(c)	% composition of N in NH_4Cl = 14/53.5 x 100% = 26.2% (3.s.f) % composition of N in $CO(NH_2)_2$ = 28/60 x 100% = 46.7% (3.s.f) **[1]** **[1m awarded if both % are correct.]**	[2]

		Therefore, urea is a better fertiliser. **[1]** Comments: If student calculated % composition of N of **only one** of the compounds correctly, but the **conclusion follows the result** of her calculations → 1 mark awarded If student calculated % composition of N of **only one** of the compounds correctly, but the conclusion **contradicts the result** of her calculation → no marks awarded If student did not show workings, but mentioned in her answer the correct % composition of N in both compounds and concluded correctly → full 2 marks If student simply concluded that urea is better as it has a higher percentage composition of N with no working or any percentages → no marks Common mistake: Many students simply counted the number of N atoms in each compound to conclude that urea is the better fertiliser.	
			Total: 10
B8			
	(a)	The conduction of electricity requires the presence of mobile charged particles **[1]**. Before the reaction, silver nitrate, a soluble ionic compound, exists as silver ions and nitrate ions in the reaction vessel, which can act as mobile charge carriers **[1]**. After the reaction, silver iodide, an insoluble ionic compound is formed and its silver and iodide ions are immobile in the crystal lattice structure. Therefore, due to a decrease in the number of mobile ions, electrical conductivity dropped **[1]**. Reject if answer - describes presence/absence of mobile/free electrons. - describes the compound as a bond. - does not specify the exacts ions that are mobile/immobile OR the compound from which the ions belong to. - contains incorrect chemical name or formula.	[3]

<table>
<tr><td></td><td></td><td>- describes reasons for the electrical conductivity of the mixture after AgI was removed.</td><td></td></tr>
<tr><td></td><td>(b)(i)</td><td>Percentage of iodine in yellow solid = 100 – 45.6 – 17.8 = 36.6%</td><td>[1]</td></tr>
<tr><td></td><td>(b)(ii)</td><td>
<table>
<tr><th></th><th>iodine</th><th>nitrate</th><th>pyridine</th></tr>
<tr><td>% comp. by mass</td><td>36.6</td><td>17.8</td><td>45.6</td></tr>
<tr><td>No. of mol</td><td>$\frac{36.6}{127}$ = 0.28819 mol</td><td>$\frac{17.8}{62}$ = 0.28710 mol</td><td>$\frac{45.6}{79}$ = 0.57722 mol [1]</td></tr>
<tr><td>Simplest ratio</td><td>1.0038
= 1</td><td>1</td><td>2.0105
= 2</td></tr>
<tr><td></td><td>1</td><td>1</td><td>2 [1] ECF given if mole-to-ratio conversion is correct</td></tr>
</table>
Empirical formula of yellow solid is $(C_{10}H_{10}N_2)NO_3I$. [1]

ECF given if formula is correct based on the ratio and chemical formulae used in the calculation.

Accept empirical formula if number of atoms for each element is correct.

Common mistakes:
- Confusion between nitrate (NO_3^-) and nitride (N^{3-}) ions
- Using wrong Ar or Mr value for calculations.
- Lack of proper labels
- Rounding off calculated values from the start resulted in inaccuracies.</td><td>[3]</td></tr>
<tr><td></td><td>(b)(iii)</td><td>Molar mass of yellow solid = 347g/mol

n[10(12) + 10(1) + 2(14) +1(127) + 1(14) + 3(16)] = 347

n = 1

Molecular formula of the yellow solid is $(C_{10}H_{10}N_2)NO_3I$. [1]</td><td>[1]</td></tr>
</table>

		Award ECF if calculation based on empirical formula in (b)(ii) can be rounded off to 1 and molecular formula is written correctly.	
	(c)	Mr of KIO_3 = [1(39) + 1(127)+3(16)] = 214 No. of mol of KIO_3 used = 3/214 = 0.014019 mol. No. of mol of $KICl_4$ formed = 0.014019 mol. Theorectical mass of $KICl_4$ = 0.014019 x [1(39) + 127 + 4(35.5) = 4.3178 g **[1]** % yield of $KICl_4$ = 2.28/4.3178 x 100% = 52.8 % (to 3.s.f) **[1]** Common mistakes: Rounding off calculated values from the start resulted in inaccuracies.	[2]
			Total: 10
B9 Either			
	(a)(i)	2**X**OH (aq) + H_2SO_4 (aq)→ $\mathbf{X}_2SO_4$ (aq) + $2H_2O$ (l) 1m for correct, balanced equation. Ignore state symbols.	[1]
	(a)(ii)	Methyl orange **[1]**, yellow to orange **[1]**. Common mistake: Mentioning color change from alkaline to acidic range (e.g. yellow to red for methyl orange) instead of from alkaline to titration end-point. Accept if - Universal indicator, violet/blue to green. - Phenolphthalein, pink to colorless. Reject if - Phenolphthalein, pink to light pink because light pink can be achieved by simply diluting the solution containing phenolphthalein. Not an accurate indicator of neutralisation. - No mention of color change.	[2]
	(a)(iii)	$\frac{M_{XOH}V_{XOH}}{M_{acid}V_{acid}} = \frac{n_1}{n_2}$	[2]

		$\frac{M_{XOH} \times 24/1000}{1 \times 28/1000} = \frac{2}{1}$ [1] M_{XOH}= 2.33 mol/dm^3 **[1]**	
	(b)	M_r of **X**OH = 130.5/2.333 = 55.9 $\approx$ 56 **[1]** Let Ar of **X** be **y**. M_r of **X**OH = **y** +16 +1 56 = **y** +17 **y** = 39 **[1]** **y** = Potassium Deduct 1m if X=Potassium not mentioned. Award ECF if steps and deduction of element made, based on the calculated Ar value, are correct.	[2]
	(c)	2K (s) + 2HCl (aq) → 2KCl (aq) + H_2 (g) **[1]** Award ECF if equation is correct and balanced based on element deduced in (b). No. of mols of K reacted = 7.8/39 = 0.2 mol Ratio of K : H_2 = 2 : 1, therefore reacting 0.2 mol of K will result in 0.1 mol of H_2 produced. **[1]** No marks if not able to show how this is derived. ECF awarded if this deduction is correct based on equation written. Volume of H_2 produced = 0.1 x 24 = 2.4 dm^3 **[1]** ECF awarded if answer is correct based on number of mols of hydrogen gas calculated above.	[3]
			Total: 10
B9 Or			
	(a)(i)	A dibasic acid is a substance that produces two H^+ ions per molecule of acid when it is dissolved in water. **[1]** $H_2A(aq) \rightarrow 2H^+(aq) + A^{2-}(aq)$ **[1]** Accept acid dissociation equation of any dibasic acid.	[2]

		Reject if state symbols are absent.	
	(a)(ii)	In 100 cm^3 of concentration 0.100 mol/dm^3, there is 0.01 mole. **[1]** Mass of 0.01 mole = 0.01 x 150 = 1.50 g **[1]**	[2]
	(a)(iii)	Mole ratio 1 mole H_2T: 1 mole Na_2T No of mole of Na_2T = 0.01 **[1]** Relative molecular mass of Na_2T = 46 + 148 = 194 **[1]** Mass of Na_2T = 0.01 x 194 = 1.94 g **[1]**	[3]
	(a)(iv)	M_aV_a/ M_bV_b = ½ 0.1X100/0.2*x* = ½ **[1]** *x* = 100 cm^3 **[1]**	[2]
	(b)	Bubble the gas produced through limewater. A white precipitate is observed in the limewater. **[1]**	[1]
			Total: 10