1: Particles – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
1	2017	March	22
1	2017	June	21
1	2017	June	22

The mark scheme for each question is provided at the end of the document.

1 **(a)** The table shows information about some of the elements in the third period.

element	Na	Mg	A*l*	P	S	C*l*
atomic radius / nm	0.186	0.160	0.143	0.110	0.104	0.099
radius of most common ion / nm	0.095	0.065	0.050	0.212	0.184	0.181
maximum oxidation number of the element in its compounds	+1					+7

(i) Complete the table to show the maximum oxidation number of each element in its compounds. [1]

(ii) Explain why the atomic radius of elements in the third period decreases from Na to C*l*.

.....

.....

.....

.....

..... [3]

(iii) The radius of the most common ion of Mg is much smaller than the radius of the most common ion of S.

Identify both ions and explain the difference in their radii.

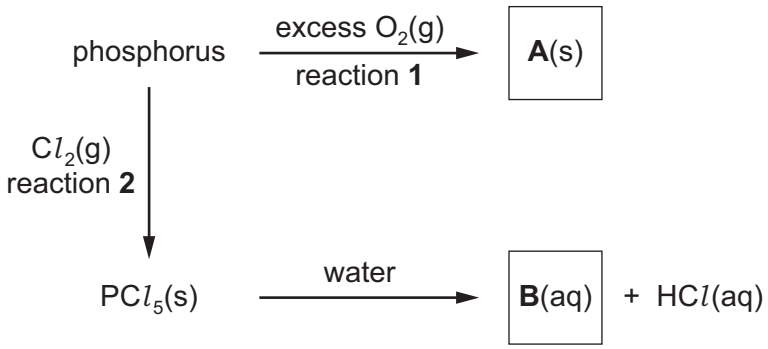
.....

.....

..... [2]

(b) Phosphorus is a non-metal in the third period. It reacts vigorously with excess oxygen but slowly with chlorine.

Some reactions of phosphorus are shown.



(i) Write an equation to represent reaction **1**, the formation of compound **A**.

..... [1]

(ii) Give **two** observations you could make in reaction **2**.

1. .....

2. .....

[2]

(iii) Name compound **B**.

..... [1]

(c) Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of cerium's compounds contain Ce^{3+} or Ce^{4+} ions.

(i) Cerium shows the same structure and bonding as a typical metal.

Draw a labelled diagram to show the structure and bonding in cerium.

[2]

(ii) Cerium(IV) oxide, CeO_2, is a ceramic.

Suggest **two** physical properties of cerium(IV) oxide.

1. .....

2. .....

[2]

(iii) A naturally occurring sample of cerium contains only **four** isotopes. Data for **three** of the isotopes are shown in the table.

isotope	^{136}Ce	^{138}Ce	^{140}Ce	^{142}Ce
relative isotopic mass	135.907	137.906	139.905	to be calculated
percentage abundance	0.185	0.251	88.450	to be calculated

The A_r of the sample is 140.116.

Use these data to calculate the **relative isotopic mass** of the fourth isotope in this sample of cerium.

Give your answer to **three** decimal places.

relative isotopic mass = ... [3]

[Total: 17]

1 Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

(a) Define the term *relative molecular mass*.

.....

.....

.....

..... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of *y*.

y = ... [1]

If you were unable to calculate values for *x* and *y* then use *x* = 4 and *y* = 10 for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

..... + ...O_2 → .....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

.....	.....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

Give your answer to **three** significant figures. Show your working.

mass = ... g [3]

[Total: 10]

1 The composition of atoms and ions can be determined from knowledge of atomic number, nucleon number and charge.

(a) Complete the table.

atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			$^{6}_{3}Li^{+}$
		23	26	32	

[2]

(b) Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B. The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

(i) Define the term *relative isotopic mass*.

.....

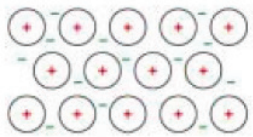
..... [2]

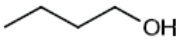
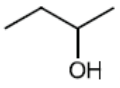
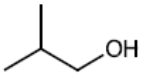
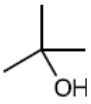
(ii) Calculate the relative isotopic mass of ^{11}B.

Give your answer to **six** significant figures. Show your working.

[2]

[Total: 6]

Question	Answer	Marks
1 (a) (i)	max O.N. | +1 | (+)2 | (+)3 | (+)5 | (+)6 | +7	1
1 (a) (ii)	(from Na to Cl) nuclear charge increases	1
	electrons are in the same shell / have same shielding	1
	greater / stronger attraction (of electrons to nucleus)	1
1 (a) (iii)	Mg^{2+} **AND** S^{2-}	1
	ion of Mg / Mg^{2+} has one fewer shell (than ion of S / S^{2-})	1
1 (b) (i)	$P_4 + 5O_2 \rightarrow P_4O_{10}$ / $2P_2O_5$	1
1 (b) (ii)	any 2 from: • yellow / green colour (of chlorine gas) disappears • white flame • white solid • solid melts	2
1 (b) (iii)	Phosphoric(V) acid	1
1 (c) (i)	 diagram showing regular arrangement of (positive) ions 1 surrounded by / sea of (delocalised) electrons 1	2
1 (c) (ii)	any 2 from: • high melting / boiling / sublimation point • electrical / thermal insulator • hard / rigid • retains strength at high temperature / pressure	2
1 (c) (iii)	**M1** % abundance of fourth isotope = 100 − (0.185 + 0.251 + 88.450) = 11.114	1
	M2 $\frac{(0.185 \times 135.907) + (0.251 \times 137.906) + (88.450 \times 139.905) + (11.114 \times RIM)}{100}$ = 140.116 ∴ (140.116 × 100) – 12434.35 = 1577.246 = 11.114 × RIM	1
	M3 RIM = $\frac{1577.246}{11.114}$ = 141.915	1
		Total: 12

Question	Answer	Marks
1 (a)	The mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecules	**1**
	Relative / compared to $\frac{1}{12}$ (the mass) of an atom of carbon-12 OR on a scale in which a carbon-12 atom / isotope has a mass of (exactly) 12 (units)	**1**
1 (b) (i)	**3**	**1**
1 (b) (ii)	**8**	**1**
1 (b) (iii)	$C_3H_8O + 4½O_2 = 3CO_2 + 4H_2O$	**1**
1 (b) (iv)	 **AND** propan-2-ol / 2-propanol	**1**
	 **AND** propan-1-ol / 1-propanol	**1**
	Alternative answers (any two):  **AND** butan-1-ol / 1-butanol  **AND** butan-2-ol / 2-butanol  **AND** (2-)methylpropan-1-ol / (2-)methyl-1-propanol  **AND** (2-)methylpropan-2-ol / (2-)methyl-2-propanol	
1 (b) (iv)	correct conversions of data to SI / consistent units p = 100 000 ; V = 20×10^{-6} ; T = 393	**1**
	calculation of n (= $pVIRT$) from M1 values $n = \frac{100 \times 10^3 \times 20 \times 10^{-6}}{8.31 \times 393}$	**1**
	calculation of mass m (= $n \times Mr$) **AND** answer correct to **3sf** $m = 6.12 \times 10^{-4} \times 60 = 0.0367$ (g) alternative answer for using $C_4H_{10}O$: $m = 6.12 \times 10^{-4} \times 74 = 0.0453$ (g)	**1**
		Total: 10

Question	Answer	Marks
1 (a)	<table><tr><th>atomic number</th><th>nucleon number</th><th>number of electrons</th><th>number of protons</th><th>number of neutrons</th><th>symbol</th></tr><tr><td></td><td>6</td><td></td><td>3</td><td>3</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td>$^{58}_{26}Fe^{3+}$</td></tr></table>	**2** 1 1
1 (b) (i)	EITHER mass of an atom / isotope relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) OR mass of one mol (atoms) of an isotope relative / compared to 1/12 (the mass) of 1 mol of C-12 OR on a scale in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	**2** 1 1
1 (b) (ii)	$\frac{(10.0129 \times 19.78) + (80.22x)}{100} = 10.8$	**1**
	x = 10.9941	**1**
		Total: 6

Notes about the mark scheme are available separately.