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F321 Style Questions from Old Specification

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Answer **all** the questions.

1 A sample of the element boron, B, was analysed using a mass spectrometer and was found to contain two isotopes, ^{10}B and ^{11}B.

(a) (i) Explain the term *isotopes*.

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.....[1]

(ii) Complete the table below for the two isotopes of boron.

isotope	protons	neutrons	electrons
^{10}B			
^{11}B			

[2]

(b) The relative atomic mass of boron in the sample analysed was 10.8.

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

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.....[3]

(ii) What does the value for the relative atomic mass suggest about the relative proportions of the boron isotopes in the sample?

Explain your reasoning.

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.....[1]

(c) The element boron was first isolated in 1808 by reacting boric acid, H_3BO_3, with potassium.

(i) In addition to boron, the reaction produces an alkali.

Suggest a balanced equation for this reaction.

.....[1]

(ii) Explain, using oxidation numbers, why boron in boric acid has been reduced.

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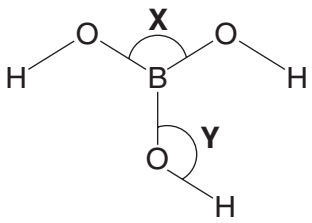
.....[2]

(d) The structure of a molecule of boric acid is shown below.

Predict values for the bond angles labelled **X** and **Y** in a boric acid molecule.

Explain your reasoning.



bond angle **X**.....

reasoning.....

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bond angle **Y**.....

reasoning.....

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.....[5]

[Total: 15]

2 Quicklime, CaO, and slaked lime, $Ca(OH)_2$, are bases made by the chemical industry with uses in building and farming.

(a) **(i)** How is quicklime made by the chemical industry?

.....[1]

(ii) Give one use of slaked lime in farming.

.....[1]

(b) Slaked lime is slightly soluble in water forming a solution commonly referred to as limewater. A student carried out a titration to find the concentration of limewater. 25.0 cm^3 of limewater was neutralised by 22.45 cm^3 of 0.0105 mol dm^{-3} nitric acid, HNO_3.

(i) Balance the equation for the reaction that takes place.

……$Ca(OH)_2(aq)$ + ……$HNO_3(aq)$ ⟶ ……$Ca(NO_3)_2(aq)$ + ……$H_2O(l)$ [1]

(ii) Calculate how many moles of HNO_3 were used.

…… mol [1]

(iii) Determine how many moles of $Ca(OH)_2$ reacted with the HNO_3.

…… mol [1]

(iv) Calculate the concentration, in mol dm^{-3}, of the $Ca(OH)_2$ in the limewater.

…… mol dm^{-3} [1]

(v) After the titration, the student allowed the water to evaporate to obtain a hydrated crystalline solid with a molar mass of 272.1 g mol^{-1}.

Determine the formula of the hydrated solid. Show your working.

[2]

(c) Limewater can be made by adding calcium metal to water.

Write an equation, with state symbols, for this reaction.

.....[2]

(d) When calcium metal reacts, each calcium atom loses two electrons. The energy change required to convert Ca atoms into Ca^{2+} ions involves both first and second ionisation energies. The first and second ionisation energies of calcium are shown below.

ionisation number	1st	2nd
ionisation energy / kJ mol^{-1}	578	1145

(i) Write an equation, including state symbols, that represents the second ionisation energy of calcium.

.....[2]

(ii) Calculate how much energy, in kJ, would be needed to form 5.00 g of Ca^{2+}(g) ions from Ca(g).

Give your answer to three significant figures.

answer = ... kJ [3]

(iii) The first ionisation energies of the elements in Group 2 show a trend.

State and explain this trend.

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.....[4]

[Total: 19]

3 This question is about the chemistry of chlorine and its compounds.

(a) Complete the electronic configuration of an atom of C*l*.

$1s^2$ .....[1]

(b) Chlorine reacts with magnesium to form magnesium chloride.

$$Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$$

(i) Draw a '*dot-and-cross*' diagram for $MgCl_2$.

[2]

(ii) Solid $MgCl_2$ does not conduct electricity but solid magnesium does.

Solid $MgCl_2$ dissolves in water and the resulting solution does conduct electricity.

Explain these observations.

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.....[3]

(c) Chlorine and magnesium are both elements in Period 3 of the Periodic Table. The radius of a C*l* atom is smaller than that of an atom of Mg.

Explain why.

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.....[3]

(d) Bleach is a solution of sodium chlorate(I), NaC*l*O, made by reacting chlorine with aqueous sodium hydroxide.

$$Cl_2(g) + 2NaOH(aq) \longrightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$$

A student prepared some bleach by reacting 145 cm^3 of chlorine gas with an aqueous solution containing 0.0100 mol NaOH.

Under these conditions, 1.00 mol of $Cl_2(g)$ has a volume of 24.0 dm^3.

Determine whether Cl_2 or NaOH was in excess of its reacting quantity.

Show all your working.

[2]

(e) You are supplied with two solutions: NaC*l*(aq) and NaBr(aq).

Outline how you could distinguish between these two solutions using simple experiments. Include relevant equations.

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[Total: 15]

4 In this question, one mark is available for the quality of spelling, punctuation and grammar.

Water, methane and hydrogen chloride all have simple molecular structures but differ in their intermolecular forces.

(a) Describe, with the aid of a diagram, the hydrogen bonding in water.

State and explain **two** anomalous properties of water in terms of this bonding.

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(b) The boiling points of methane and hydrogen chloride are shown in the table below.

substance	boiling point / °C
methane	–164
hydrogen chloride	–85

Explain why methane and hydrogen chloride have different boiling points.

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.....[3]

Quality of Written Communication [1]

[Total: 11]

END OF QUESTION PAPER