HIGHER

C1H Atomic Structure and the Periodic Table: Higher Tier Practice

Total Marks

AQA 8462 · Calculator allowed · about 110 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Define the term proton number (also called atomic number).

(Total for Question 1 is 1 mark)

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2 An element has two naturally occurring isotopes. Isotope A has mass number 35 and abundance 75.8%. Isotope B has mass number 37 and abundance 24.2%.

(a) Calculate the relative atomic mass (Ar) of the element to two decimal places. **(2)**

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(Total for Question 2 is 2 marks)

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3 Write the full electron configuration (shell notation) for an ion of sulphur with a 2- charge, S2-.

(a) Give the electron configuration in shell notation, e.g. 2,8,6 for neutral sulphur. Then give configuration for S2-. **(3)**

(Total for Question 3 is 3 marks)

4 Atoms of element X (Group 1) and element Y (Group 2) both react to form positive ions by losing electrons from their outer shell to reach a full outer shell (a stable electron arrangement). Removing one electron from an atom of X is relatively easy, but removing a second electron from the X+ ion formed is much harder. Removing two electrons from an atom of Y, to form a 2+ ion, happens comparatively easily. Explain this pattern in terms of the electronic structures of X and Y.

(Total for Question 4 is 3 marks)

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5 A student investigates the reaction of lithium with water. The equation is: 2Li + 2H2O -> 2LiOH + H2. The student reacts 3.0 g of lithium with excess water.

(a) Calculate the number of moles of lithium used. (Ar: Li = 6.94, use 6.94) **(2)**

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(b) Calculate the volume of hydrogen gas produced at room conditions if 1 mol of gas occupies 24.0 dm3. **(2)**

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(Total for Question 5 is 4 marks)

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6 State one chemical test that distinguishes between a metal and a non-metal, and describe the expected observation for each.

(Total for Question 6 is 2 marks)

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7 An unknown ionic compound contains elements A and B. Element A forms A2+ ions and element B forms B3- ions. The empirical formula of the compound is A3B2.

(Total for Question 7 is 4 marks)

8 A sample of magnesium oxide is made by burning 1.20 g of magnesium in oxygen. The product has mass 2.00 g.

(a) Calculate the mass of oxygen that combined with the magnesium. **(1)**

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(b) Calculate the moles of magnesium and the moles of oxygen atoms that reacted. **(2)**
(Ar: Mg = 24.3, O = 16.0)

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(Total for Question 8 is 3 marks)

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9 Chlorine is in Group 7. Predict and explain what happens when potassium iodide solution is mixed with chlorine water.

(Total for Question 9 is 4 marks)

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10 A sample of an organic compound contains 52.2% carbon, 34.8% oxygen and 13.0% hydrogen by mass. Determine the empirical formula of the compound. (Ar: C = 12.0, H = 1.00, O = 16.0)

(Total for Question 10 is 4 marks)

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11 Explain why ionic compounds conduct electricity when molten but not when solid.

(Total for Question 11 is 3 marks)

12 A mass spectrum of element Z shows two peaks at m/z 23 and m/z 25 with relative abundances 100 and 10 respectively. Calculate the relative atomic mass of element Z to two decimal places.

(Total for Question 12 is 5 marks)

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13 Explain how the properties of elements change across Period 3 (sodium to argon). In your answer, refer to atomic structure, metallic and non-metallic character, melting point trends and a clear explanation for the change in electrical conductivity across the period. Use examples of at least two elements to support your explanation.

(Total for Question 13 is 6 marks)

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14 A student reacts an unknown metal M with excess dilute hydrochloric acid: M + 2HCl -> MCl2 + H2. A sample of 0.327 g of the metal reacts completely with the acid. Analysis of the resulting solution shows it contains 0.3545 g of chloride ions (Cl-). Determine the relative atomic mass of metal M and identify it from the candidates below. (Ar of Cl = 35.45.) Candidates: Mg (24.3), Al (27.0), Fe (55.8), Zn (65.4). Show all your working.

(Total for Question 14 is 7 marks)

15 State the electron shell arrangement for phosphorus (atomic number 15) using shell notation (for example, 2,8,5) and explain, using this arrangement, why phosphorus typically forms three covalent bonds in molecules such as PCl3.

(Total for Question 15 is 4 marks)

Mark scheme · C1H Atomic Structure and the Periodic Table: Higher Tier Practice

Question 1

- **B1** the number of protons in the nucleus of an atom (cao)
- **Answer: The number of protons in the nucleus of an atom.**

Question 2

- (a) **M1** multiplies masses by abundances and adds: (35 x 75.8) + (37 x 24.2) or equivalent
- (a) **A1** 35.48 cao
- **(a) Answer: 35.48**

Question 3

- (a) **B1** neutral S is 2,8,6 or equivalent
- (a) **M1** adds two electrons to outer shell for S2- (method)
- (a) **A1** S2- is 2,8,8 cao
- **(a) Answer: S neutral: 2,8,6. S2-: 2,8,8**

Question 4

- **B1** X, a Group 1 element, has only one electron in its outer shell, so it is lost relatively easily to leave a full, stable outer shell, forming X+
- **M1** removing a second electron from X+ would mean removing an electron from a full inner shell, which needs much more energy, so it does not happen easily
- **A1** Y, a Group 2 element, has two electrons in its outer shell, so both can be lost from that same outer shell in a similar way, forming a 2+ ion, oe
- **Answer: X (Group 1) has one outer electron, easily lost to leave a full, stable shell; removing a second electron would mean breaking into a full inner shell, needing far more energy. Y (Group 2) has two outer electrons, both of which can be lost from the same outer shell to form a 2+ ion.**

Question 5

- (a) **M1** uses n = mass / Mr: n = 3.0 / 6.94
- (a) **A1** 0.432 mol to 3 s.f. cao
- **(a) Answer: 0.432 mol**
- (b) **M1** uses mol ratio: from equation 2Li -> H2 so moles H2 = moles Li / 2
- (b) **A1** 5.18 dm3 cao
- **(b) Answer: 5.18 dm3**

Question 6

- **B1** test: reaction with acid or with sodium hydroxide, or electrical conductivity or malleability as a physical test
- **B1** observation: metal reacts with dilute acid to produce hydrogen gas (bubbles), non-metal does not; or metal conducts electricity, non-metal does not, oe
- **Answer: Example: React with dilute acid. A metal produces bubbles of hydrogen gas; a non-metal does not react in the same way. Alternatively, test conductivity: metals conduct electricity, non-metals do not.**

Question 7

- **M1** uses charges A2+ and B3- to find least common multiple approach
- **M1** shows balancing: 3 x A2+ gives total +6, 2 x B3- gives total -6
- **A1** states empirical formula A3B2 cao
- **B1** explains ionic compound is neutral because total positive and negative charges balance
- **Answer: A3B2**

Question 8

- (a) **B1** 0.80 g cao
- **(a) Answer: 0.80 g**
- (b) **M1** calculates moles Mg: 1.20 / 24.3 and moles O atoms: 0.80 / 16.0
- (b) **A1** 0.0494 mol Mg and 0.0500 mol O (or 0.0494 and 0.0500) cao
- **(b) Answer: Moles Mg = 0.0494 mol; moles O = 0.0500 mol**

Question 9

- **B1** prediction: iodine is displaced from potassium iodide; solution turns brown/orange or brown solution observed
- **M1** reason: chlorine is more reactive than iodine and oxidises I- to I2
- **A1** states chloride ions are formed: Cl2 + 2I- -> 2Cl- + I2 or equivalent
- **B1** observational detail: brown/orange colour of iodine or purple with starch if added
- **Answer: Iodine is displaced so the solution turns brown/orange as I2 forms; chlorine oxidises I- to I2 and is reduced to Cl-.**

Question 10

- **M1** convert percentages to moles: 52.2/12.0, 13.0/1.00, 34.8/16.0
- **M1** divide by smallest number to find simplest ratio
- **A1** gives integer ratio C2H6O (cao)
- **B1** shows working: moles C 4.35, H 13.0, O 2.175 => ratio 2:6:1, i.e. C2H6O
- **Answer: C2H6O**

Question 11

- **B1** solid ionic lattice has ions in fixed positions so they cannot move
- **M1** when molten the lattice breaks down and ions are free to move
- **A1** free moving ions carry charge so molten ionic compound conducts electricity
- **Answer: In solid ionic compounds ions are fixed in a lattice and cannot move so they do not conduct. When molten the lattice breaks down so ions are free to move and these mobile ions carry charge, allowing conduction.**

Question 12

- **M1** multiplies masses by abundances and adds: (23 x 100) + (25 x 10)
- **M1** divides by total abundance: / (100 + 10)
- **A1** gives Ar = 23.18 (or 23.18 to two dp) cao
- **B1** shows intermediate arithmetic: 2300 + 250 = 2550; 2550 / 110 = 23.1818...
- **B1** states answer to two decimal places: 23.18 cao
- **Answer: 23.18**

Question 13

- **Level 1** (1-2): Simple statements about one or two properties across the period with little reference to atomic structure or examples. Limited use of correct scientific terms.
- **Level 2** (3-4): Clear descriptions of changes across the period with reference to electron arrangement and examples. Some explanation of trends in metallic to non-metallic character and melting points, but lacking detail or linking statements.
- **Level 3** (5-6): Detailed and coherent explanation linking atomic structure to the trends across Period 3. Discusses metallic to non-metallic change, explains melting point pattern with structure and bonding (including exceptions), and explains electrical conductivity changes with suitable examples and correct terminology.
- **Indicative content:**
  - Across Period 3 atomic number increases so number of protons and electrons increases; electrons fill the same shell (third shell) so atoms get smaller due to increased nuclear attraction.
  - Metallic character (eg Na, Mg, Al) on left: metals with metallic bonding, delocalised electrons, conduct electricity and have high melting points depending on strength of metallic bond.
  - Non-metallic character (eg P, S, Cl) on right: simple molecular or atomic structures with covalent bonding or van der Waals forces; lower melting points for P, S and very low for Cl because of weak intermolecular forces; argon is monatomic with very low melting point due to weak van der Waals forces.
  - Melting point trend: rises from Na to Al as metallic bonding gets stronger (more delocalised electrons and higher charge density), then falls across to Si and molecular substances where covalent network in Si gives high melting point, then drops for P and S then very low for Cl and Ar. Mention Si as a high melting point due to giant covalent structure.
  - Electrical conductivity: metals conduct in solid state due to delocalised electrons (eg Na, Al); Si conducts less but can conduct when doped and has covalent network; non-metals (P, S, Cl, Ar) do not conduct as solids or liquids because no free moving charged particles. Use examples (Na conducts, Cl does not).
  - Link atomic structure to properties: number of delocalised electrons, type of bonding and structure determines melting point and conductivity; increasing proton number pulls electrons inwards affecting bonding strength.

Question 14

- **B1** recognises that moles of chloride ions must be found first, using n = mass / Ar
- **M1** substitutes: n(Cl-) = 0.3545 / 35.45
- **A1** n(Cl-) = 0.0100 mol cao
- **M1** uses the equation (1 mol M produces 2 mol Cl-) to find moles of M: n(M) = n(Cl-) / 2
- **A1** n(M) = 0.0100 / 2 = 0.00500 mol cao
- **M1** substitutes into Mr = mass / moles: Mr(M) = 0.327 / 0.00500
- **A1** Mr(M) = 65.4, identifying M as zinc (Zn) cao
- **Answer: Mr(M) = 65.4, so the metal is zinc.**

Question 15

- **B1** states electron arrangement: 2,8,5 cao
- **M1** identifies that phosphorus has 5 electrons in its outer (third) shell
- **A1** explains phosphorus needs to share three more electrons to fill its outer shell (up to 8), so it forms three covalent bonds, eg with three chlorine atoms as in PCl3
- **B1** links to periodic table position: phosphorus is in Group 5, and elements in this group have five outer electrons and typically form three covalent bonds to complete their outer shell
- **Answer: Electron arrangement: 2,8,5. Phosphorus has five electrons in its outer shell so needs to share three more to complete it (reach 8); this is why it forms three covalent bonds, for example in PCl3. As a Group 5 element, this pattern is typical of elements with five outer electrons.**