C1bD The Periodic Table: Groups and Trends: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Give the name of the group in the Periodic Table that contains elements with a full outer shell of electrons and which are very unreactive.

(Total for Question 1 is 1 mark)

2 State the group number (as printed on many Periodic Tables) containing the alkali metals and give one common property of alkali metals.

(Total for Question 2 is 2 marks)

3 Chlorine is in Group 7 (the halogens). State the charge of a typical halide ion formed by chlorine and give the electronic reason for this charge.

(Total for Question 3 is 2 marks)

4 Sodium (Na) has atomic number 11 and mass number 23. Calculate the number of protons, neutrons and electrons in a neutral sodium atom.

(a) Number of protons **(1)**

....

(b) Number of neutrons **(1)**

....

(c) Number of electrons **(1)**

....

(Total for Question 4 is 3 marks)

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5 An unknown element X forms an oxide with formula X2O3. What is the likely group or typical ionic charge of X? Explain your answer in terms of electrons transferred.

(Total for Question 5 is 3 marks)

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6 A sample of magnesium oxide contains 0.0200 mol of MgO. Calculate the mass of oxygen present in the sample. (Relative atomic masses: O = 16.0, Mg = 24.3).

(a) Calculate the moles of oxygen atoms present. **(1)**

....

(b) Calculate the mass of oxygen in grams. **(3)**

....

(Total for Question 6 is 4 marks)

7 A student compares the first ionisation energies of three elements A, B and C and finds: A = 738 kJ/mol, B = 496 kJ/mol, C = 2070 kJ/mol. Place the elements in order of increasing atomic radius and explain the reasoning.

(Total for Question 7 is 3 marks)

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8 The boiling points of the Group 7 elements (the halogens) increase down the group. Explain, in terms of structure and bonding, why the boiling point increases from fluorine to iodine.

(Total for Question 8 is 4 marks)

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9 A chemist measures the relative atomic masses of two isotopes of element Y and finds isotope Y-28 has abundance 92.2% and isotopic mass 27.976 u, and isotope Y-29 has abundance 7.8% and isotopic mass 28.976 u. Calculate the relative atomic mass (Ar) of element Y. Show your calculation and give the Ar to one decimal place.

(Total for Question 9 is 3 marks)

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10 The required practical 'Investigating reactivity of metals with water' asks students to compare the reactivity of magnesium and calcium by reacting small pieces of each metal with excess water and measuring the volume of hydrogen produced after 2 minutes. Suggest two control variables that must be kept constant to make the comparison fair, and give one improvement to the method to reduce random error in the measured hydrogen volumes.

(Total for Question 10 is 4 marks)

11 A student titrates a solution of hydrochloric acid with sodium hydroxide. The student records mean titre 25.40 cm3 and uses 0.100 mol/dm3 NaOH. Calculate the number of moles of NaOH used in the titre. (1 dm3 = 1000 cm3).

(Total for Question 11 is 3 marks)

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12 An experimental student measured the melting points of three unknown elements and obtained: element P mp 24 degrees C, element Q mp 183 degrees C, element R mp 660 degrees C. The student concludes P is a molecular substance, Q is a metal and R is a giant covalent structure. Evaluate whether these conclusions are justified, giving reasons for each element.

(Total for Question 12 is 4 marks)

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13 A piece of unknown metal Z reacts with dilute sulfuric acid to produce hydrogen gas and a solution containing Z2+ ions. A student measures the volume of hydrogen produced over time and obtains a curve that flattens off before all metal appears to have reacted. Suggest two possible experimental errors that could cause the curve to flatten early and explain how each would affect the result.

(Total for Question 13 is 4 marks)

14 Ionic radius trends: Explain why the ionic radius of a 2+ ion is usually smaller than the radius of its neutral atom, and predict whether a 2- ion would be larger or smaller than its neutral atom. Give one clear reason for each comparison.

(Total for Question 14 is 5 marks)

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15 Extended response (6 marks). Explain how the properties of elements change across Period 3 (from sodium to argon). In your answer describe changes in atomic structure that cause the trends in melting point, electrical conductivity and typical bonding types across the period.

(Total for Question 15 is 6 marks)

Mark scheme · C1bD The Periodic Table: Groups and Trends: Exam Drill

Question 1

- **B1** noble gases or group 0 or group 18
- **Answer: Noble gases**

Question 2

- **B1** group 1
- **B1** one property such as: react with water to produce hydrogen, are soft, have low melting points, or form +1 ions, oe
- **Answer: Group 1; they react with water to produce hydrogen (and form hydroxides).**

Question 3

- **B1** -1 charge
- **B1** because chlorine gains one electron to complete its outer shell (to achieve a full outer shell), oe
- **Answer: Charge -1, because chlorine gains one electron to complete its outer shell.**

Question 4

- (a) **B1** 11 protons (atomic number 11)
- **(a) Answer: 11 protons**
- (b) **B1** 12 neutrons (mass number 23 minus proton number 11)
- **(b) Answer: 12 neutrons**
- (c) **B1** 11 electrons (neutral atom has same electrons as protons)
- **(c) Answer: 11 electrons**

Question 5

- **B1** X likely forms a +3 ion (for example group 3 or an element that commonly forms +3)
- **B1** because 3 oxide ions (each $O2-$) give total charge -6 and 2 X must give +6 so each X is +3
- **B1** thus each X atom loses three electrons to oxygen, oe
- **Answer: X is likely +3 (group 3 or a +3 ion), because 2 X give +6 to balance 3 $O2-$ so each X has charge +3.**

Question 6

- (a) **B1** 0.0200 mol oxygen (1 mol MgO contains 1 mol O)
- **(a) Answer: 0.0200 mol O**
- (b) **M1** uses m = n x Ar: mass = 0.0200 x 16.0
- (b) **A1** 0.320 g cao
- (b) **B1** includes unit g
- **(b) Answer: 0.320 g**

Question 7

- **B1** lower first ionisation energy generally implies outer electron is less strongly held and the atom is larger
- **B1** order of increasing atomic radius: C (2070) < A (738) < B (496)
- **B1** justification: C has very high ionisation energy so outer electron strongly bound (small radius); B has lowest so largest radius, oe
- **Answer: Increasing atomic radius: C, A, B. C has highest ionisation energy so smallest radius; B has lowest ionisation energy so largest radius.**

Question 8

- **B1** halogens are simple molecules (F2, Cl2, Br2, I2) with van der Waals forces between molecules
- **B1** down the group molecules get larger with more electrons so stronger van der Waals forces
- **B1** stronger intermolecular forces require more energy to overcome so higher boiling point down the group
- **B1** example: I2 has more electrons and stronger van der Waals forces than F2, so higher boiling point, oe
- **Answer: Because halogen molecules become larger with more electrons down the group, they have stronger van der Waals forces between molecules, so more energy is needed to separate them and the boiling point rises.**

Question 9

- **M1** correct weighted mean calculation: (0.922 x 27.976) + (0.078 x 28.976)
- **A1** Ar = 28.054, rounds to 28.1 to 1 dp cao
- **B1** shows working or equivalent (calculation steps) or units u
- **Answer: 28.1 u**

Question 10

- **B1** control variable 1: same mass or surface area of metal samples
- **B1** control variable 2: same temperature of the water (or same volume of water)
- **B1** improvement: repeat each measurement and take mean to reduce random error
- **B1** alternative improvement: use a gas syringe rather than displacement to measure hydrogen more precisely, oe
- **Answer: Keep mass/surface area of metal and temperature (and volume) of water constant; repeat each test and take the mean (or use a gas syringe) to reduce random error.**

Question 11

- **M1** convert volume to dm3 and substitute: n = 0.100 x (25.40/1000)
- **A1** 0.00254 mol cao
- **B1** includes correct units mol
- **Answer: 0.00254 mol**

Question 12

- **B1** P mp 24 C is consistent with a simple molecular substance (low mp) but could also be a metal with low mp; justification: weak intermolecular forces give low mp
- **B1** Q mp 183 C could be a metal or giant ionic or high boiling molecular; justify: metals often have moderate to high mps due to metallic bonding but more info (conductivity) needed
- **B1** R mp 660 C is not sufficient alone to prove giant covalent (e.g. metals and ionic solids can have high mp); need other tests like hardness or electrical conductivity
- **B1** conclusion: student has plausible ideas but each claim needs supporting tests; award conclusion-based judgement
- **Answer: P: plausible molecular (low mp due to weak intermolecular forces). Q: could be a metal (metallic bonding) but not certain without conductivity test. R: high mp suggests strong bonding but could be metal/ionic; further tests needed to confirm giant covalent.**

Question 13

- **B1** error 1: gas lost from apparatus (poor seal) causing measured volume to stop increasing; effect: recorded volume lower and curve flattens before reaction complete
- **B1** error 2: acid becomes too dilute (consumed locally) or metal surface becomes passivated e.g. oxide layer forms; effect: reaction rate falls giving early flattening
- **B1** explain fix for error 1: ensure gas syringe sealed or use delivery tube submerged properly
- **B1** explain fix for error 2: use excess acid or remove oxide layer before test
- **Answer: Possible errors: poor seal so hydrogen escapes (gives low measured volume and curve flattens early); metal surface passivation or local acid depletion (reaction slows and curve flattens). Fix by sealing apparatus and using fresh metal surface or excess acid.**

Question 14

- **B1** 2+ ion is smaller because loss of electrons reduces electron-electron repulsion and same number of protons pull fewer electrons more strongly
- **B1** loss of outer shell electrons may mean fewer occupied shells so radius decreases
- **B1** 2- ion is larger because gain of electrons increases electron-electron repulsion and outer shell electron shielding increases
- **B1** extra electrons mean increased shielding so nucleus pulls less strongly on outer electrons, increasing radius
- **B1** include example: Na -> Na2+ is smaller; O -> O2- is larger, oe
- **Answer: A 2+ ion is smaller than its neutral atom because loss of electrons reduces electron-electron repulsion and the remaining electrons are pulled in more strongly by the nucleus. A 2- ion is larger because added electrons increase repulsion and shielding, so the outer electrons are held less tightly.**

Question 15

- **Level 3** (5-6): Detailed explanation linking changes in atomic structure to observed trends across Period 3 with clear, correct examples and development.
- **Level 2** (3-4): Clear explanation with some links between structure and properties and at least one correct example but missing some development.
- **Level 1** (1-2): Simple statements about trends or structure with limited or no linking; minimal examples.
- **Indicative content:**
  - Across Period 3, number of protons increases so nuclear charge increases; electrons are added to same shell so shielding stays similar, increasing attraction on outer electrons.
  - Bonding types change: metals (Na, Mg, Al) show metallic bonding (delocalised electrons) with high conductivity for these metals; silicon is giant covalent with high melting point and no free electrons for conduction in solid; phosphorus, sulfur, chlorine are simple molecular with low melting/boiling points due to weak van der Waals forces; argon is monatomic noble gas with very low mp.
  - Melting point trend: increases from Na to Al due to stronger metallic bonding (more delocalised electrons and higher charge density), peaks at silicon (giant covalent highest), then drops for P, S, Cl and Ar because of molecular structures with weak intermolecular forces.
  - Electrical conductivity: metals conduct (delocalised electrons), silicon conducts poorly as a solid (giant covalent with no delocalised electrons), molecular elements do not conduct, argon does not conduct.
  - Use of examples and linking: e.g. Na metallic with low mp compared to Si; Si very high mp due to strong covalent network; Cl_2 low bp due to weak van der Waals.