2.13 The Periodic Table: Groups and Trends: Test Pack

AQA 8464 · Calculator allowed · about 40 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 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 2 is 2 marks)

3 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 3 is 4 marks)

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4 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 and how to fix each.

(Total for Question 4 is 4 marks)

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5 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 5 is 4 marks)

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6 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 6 is 4 marks)

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7 An experimental student measured the melting points of three unknown elements and obtained: element P mp 24°C, element Q mp 183°C, element R mp 660°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 7 is 4 marks)

8 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 two reasons for each comparison and include an example for each.

(Total for Question 8 is 5 marks)

9 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 9 is 3 marks)

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Mark scheme · 2.13 The Periodic Table: Groups and Trends: Test Pack

Question 1

noble gases or group 0 or group 18 **B1**

Answer: Noble gases

Question 2

-1 charge **B1**

because chlorine gains one electron to complete its outer shell (to achieve a full outer shell), oe **B1**

Answer: Charge -1, because chlorine gains one electron to complete its outer shell.

Question 3

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 **B1**

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 4

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 **B1**

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 5

(a) 0.0200 mol oxygen (1 mol MgO contains 1 mol O) **B1**

(a) Answer: 0.0200 mol O

(b) uses m = n x Ar: mass = 0.0200 x 16.0 **M1**

(b) 0.320 g cao **A1**

(b) includes unit g **B1**

(b) Answer: 0.320 g

Question 6

halogens are simple molecules (F_2, Cl_2, Br_2, I_2) 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: I_2 has more electrons and stronger van der Waals forces than F_2, so higher boiling point, oe **B1**

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 7

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 **B1**

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 8

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: Mg -> Mg^{2+} is smaller; O -> O^{2-} is larger, oe **B1**

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.

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Question 9

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	**B1**

Answer: Increasing atomic radius: C, A, B. C has highest ionisation energy so smallest radius; B has lowest ionisation energy so largest radius.

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