K7D Atoms, Elements and Compounds: Exam Drill

AQA AQA KS3 Science - Chemistry · Calculator allowed · about 75 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Which of the following is a mixture rather than a pure element or compound?

- ☐ A) Neon gas
- ☐ B) Crude oil
- ☐ C) Copper metal
- ☐ D) Carbon dioxide

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2 In a neutral atom, which two subatomic particles are always present in equal numbers?

- ☐ A) protons and neutrons
- ☐ B) protons and electrons
- ☐ C) neutrons and electrons
- ☐ D) protons, neutrons and electrons are always equal

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3 Define each of the following terms in your own words.

(a) Define the term 'element'. **(1)**

(b) Define the term 'compound'. **(1)**

(c) Define the term 'mixture'. **(1)**

4 The maximum number of electrons that can occupy the first three electron shells (energy levels) of an atom are 2, then 8, then 8. Use this rule and the atomic number (the number of protons, which equals the number of electrons in a neutral atom) to work out the electron configuration of each atom below.

(a) Oxygen has atomic number 8. State its electron configuration (the number of electrons in each shell). **(2)**

(b) Aluminium has atomic number 13. State its electron configuration. **(2)**

(c) Calcium has atomic number 20. State its electron configuration. **(2)**

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5 Dry air is a mixture of gases in these approximate percentages by volume: nitrogen (N_2) 78%, oxygen (O_2) 21%, argon (Ar) 0.9%, carbon dioxide (CO_2) 0.04%, with the remainder made up of other gases.

(a) Calculate the percentage of dry air made up of 'other gases'. **(2)**

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(b) Classify nitrogen (N_2), argon (Ar) and carbon dioxide (CO_2) as an element or a compound. **(3)**

(c) State why 'air' itself is described as a mixture rather than a compound. **(1)**

6 Balance each symbol equation below by writing the correct numbers in front of the formulas where needed.

(a) Balance: Ca + O2 -> CaO **(2)**

(b) Balance: H2 + Cl2 -> HCl **(2)**

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7 Iron filings and powdered sulfur are mixed together and then heated strongly. They react to form the compound iron sulfide.

(a) Write a word equation for this reaction. **(2)**

(b) The unbalanced symbol equation is Fe + S -> FeS. State whether this equation needs balancing, and explain your reasoning. **(2)**

8 Use these relative atomic masses (Ar): H = 1, N = 14, Mg = 24, O = 16, Na = 23, C = 12.
The relative formula mass (Mr) of a substance is found by adding together the Ar values of all the atoms shown in its formula.

(a) Calculate the relative formula mass (Mr) of ammonia, NH_3. **(2)**

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(b) Calculate the relative formula mass (Mr) of magnesium oxide, MgO. **(2)**

.....

(c) Calculate the relative formula mass (Mr) of sodium carbonate, Na_2CO_3. **(3)**
Show your working.

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9 Rock salt is a naturally occurring mixture of salt (sodium chloride) and insoluble rocky material (mostly sand and grit). A technician wants to obtain pure, dry salt crystals from 40 g of rock salt.

(a) Below are four steps from the method, listed in the wrong order. 1: Filter the mixture to remove the insoluble rock. 2: Crush the rock salt into small pieces using a pestle and mortar. 3: Gently evaporate the filtrate until dry salt crystals remain. 4: Add water and stir well to dissolve the salt. Write the four steps in the correct order. **(4)**

(b) Explain why the rock salt is crushed before adding water. **(1)**

(c) The technician recovers 34.2 g of dry salt crystals from the 40 g of rock salt. Calculate the percentage of the original 40 g mass that was recovered as salt crystals. **(2)**

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10 Classify each of these elements as a metal or a non-metal: potassium, phosphorus, silver, neon, iron, bromine.

(3)

11 Carbon has several isotopes, including carbon-12 and carbon-14. Both have atomic number 6.

(a) Explain what is meant by the term isotope, using carbon-12 and carbon-14 as examples. **(3)**

(b) Calculate the number of neutrons in an atom of carbon-14. **(1)**

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12 Required practical: a long glass tube, 60 cm in length, is set up horizontally. A piece of cotton wool soaked in concentrated ammonia solution is placed at one end (end A) and a piece of cotton wool soaked in concentrated hydrochloric acid is placed at the other end (end B) at the same moment. The two gases diffuse along the tube and react where they meet, forming a white ring of solid ammonium chloride. After 60 seconds, the ring has formed 36 cm from end A.

(a) Calculate the mean rate at which the ring formed, in cm per second, measuring the distance from end A. **(2)**

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(b) Explain, in terms of particles, why a white ring forms where the two gases meet, rather than the gases simply staying at each end of the tube. **(2)**

(c) The ring forms closer to the hydrochloric acid end (end B) than to the ammonia end (end A). Suggest one reason for this, based on the particles involved. **(2)**

13 From Question 8, the relative formula mass (Mr) of magnesium oxide (MgO) is 40, and magnesium has relative atomic mass (Ar) 24.

(a) Calculate the percentage by mass of magnesium in magnesium oxide. **(2)**

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(b) Calculate the percentage by mass of oxygen in magnesium oxide. **(1)**

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(c) A sample of magnesium oxide has a mass of 15 g. Assuming the same percentage composition, calculate the mass of magnesium it must have contained. **(2)**

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14 For each statement, identify whether it is True or False. If a statement is false, give the correct version.

(a) An atom of any element always has the same number of protons as electrons, if the atom is neutral. **(1)**

(b) The relative formula mass of a compound is always found by simply adding up the atomic numbers of the atoms in its formula. **(1)**

(c) A molecule of a compound must contain atoms of at least two different elements. **(1)**

(d) Mixtures always have a fixed, unchanging ratio of their components, in the same way that compounds do. **(1)**

15 State the number of atoms of each element present in the following formulas.

(a) State the number of atoms of each element in one molecule of glucose, $C_6H_{12}O_6$. **(3)**

(b) State the number of atoms of each element in one formula unit of ammonium sulfate, $(NH_4)_2SO_4$. **(2)**

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16 State the general term used to describe the strong forces that hold atoms together within a compound.

(1)

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17 When 12 g of carbon is completely burned in oxygen, 44 g of carbon dioxide gas is produced. Calculate the mass of oxygen that must have reacted with the carbon, using the idea of conservation of mass.

(3)

18 Iron filings and powdered sulfur can be mixed together to make a grey powder, or heated together to react and form the compound iron sulfide. Explain how you could tell, using simple tests, whether a grey powder sample is the original iron-and-sulfur mixture or the compound iron sulfide, and explain why the two samples behave differently. Refer to separation methods and particle theory in your answer.

(6)

Mark scheme · K7D Atoms, Elements and Compounds: Exam Drill

Question 1

- **B1** B (crude oil) cao
- Answer: **B) Crude oil**

Question 2

- **B1** B cao
- Answer: **B) protons and electrons**

Question 3

- (a) **B1** a substance made of only one type of atom, oe
- (a) Answer: **A substance made of only one type of atom.**
- (b) **B1** two or more different elements chemically joined (bonded) together in fixed proportions, oe
- (b) Answer: **Two or more different elements chemically joined together in fixed proportions.**
- (c) **B1** two or more substances that are not chemically joined together and can be present in any (variable) proportion, oe
- (c) Answer: **Two or more substances not chemically joined together, which can be present in any proportion.**

Question 4

- (a) **M1** first shell filled with 2 electrons
- (a) **A1** remaining 6 electrons in the second shell: 2,6 cao
- (a) Answer: **2,6**
- (b) **M1** first two shells filled (2 and 8 electrons)
- (b) **A1** remaining 3 electrons in the third shell: 2,8,3 cao
- (b) Answer: **2,8,3**
- (c) **M1** first three shells filled (2, 8 and 8 electrons)
- (c) **A1** remaining 2 electrons in the fourth shell: 2,8,8,2 cao
- (c) Answer: **2,8,8,2**

Question 5

- (a) **M1** 78 + 21 + 0.9 + 0.04 = 99.94
- (a) **A1** 100 - 99.94 = 0.06% cao
- (a) Answer: **0.06%**
- (b) **B1** nitrogen = element
- (b) **B1** argon = element
- (b) **B1** carbon dioxide = compound
- (b) Answer: **Nitrogen: element. Argon: element. Carbon dioxide: compound.**
- (c) **B1** the gases are not chemically combined/bonded together and can be present in variable proportions, oe
- (c) Answer: **The gases in air are not chemically combined and their proportions can vary.**

Question 6

- (a) **M1** 2Ca and 2CaO correctly placed
- (a) **A1** 2Ca + O2 -> 2CaO fully balanced cao
- (a) Answer: **2Ca + O2 -> 2CaO**
- (b) **M1** 2HCl correctly placed on the right
- (b) **A1** H2 + Cl2 -> 2HCl fully balanced cao
- (b) Answer: **H2 + Cl2 -> 2HCl**

Question 7

- (a) **B1** iron + sulfur ->
- (a) **B1** -> iron sulfide
- (a) Answer: **iron + sulfur -> iron sulfide**
- (b) **B1** no, it does not need balancing (it is already balanced)
- (b) **B1** there is 1 iron atom and 1 sulfur atom on each side of the equation, oe
- (b) Answer: **No, it is already balanced: 1 iron atom and 1 sulfur atom appear on each side.**

Question 8

- (a) **M1** 14 + (1 x 3)
- (a) **A1** = 17 cao
- (a) Answer: **Mr(NH3) = 17**
- (b) **M1** 24 + 16
- (b) **A1** = 40 cao
- (b) Answer: **Mr(MgO) = 40**
- (c) **M1** identifies 2 Na, 1 C and 3 O atoms from the formula
- (c) **M1** (23 x 2) + 12 + (16 x 3)
- (c) **A1** = 106 cao
- (c) Answer: **Mr(Na2CO3) = 106**

Question 9

- (a) **B1** step 2 first (crush the rock salt)
- (a) **B1** step 4 second (add water and stir)
- (a) **B1** step 1 third (filter)
- (a) **B1** step 3 fourth (evaporate) ft consistent logical order
- (a) Answer: **2, 4, 1, 3**
- (b) **B1** crushing increases the surface area of the rock salt, so it dissolves more quickly/completely, oe
- (b) Answer: **Crushing increases the surface area of the rock salt, so the salt dissolves more quickly and completely.**
- (c) **M1** 34.2 / 40
- (c) **A1** x 100 = 85.5% cao
- (c) Answer: **85.5%**

Question 10

- **B1** potassium = metal AND silver = metal both correct
- **B1** iron = metal AND phosphorus = non-metal both correct
- **B1** neon = non-metal AND bromine = non-metal both correct
- Answer: **Potassium: metal. Phosphorus: non-metal. Silver: metal. Neon: non-metal. Iron: metal. Bromine: non-metal.**

Question 11

- (a) **B1** both are atoms of carbon with the same number of protons (6), i.e. the same atomic number
- (a) **B1** they have different numbers of neutrons
- (a) **B1** this gives them different mass numbers (12 and 14) oe
- (a) Answer: **Isotopes are atoms of the same element (same number of protons) with different numbers of neutrons, and therefore different mass numbers. Carbon-12 and carbon-14 both have 6 protons but different neutron numbers.**
- (b) **B1** = 8 cao (ft candidate's own atomic number of carbon from (a) if consistent)
- (b) Answer: **8 neutrons**

Question 12

- (a) **M1** 36 / 60
- (a) **A1** 0.6 cm/s cao
- (a) Answer: **0.6 cm/s**
- (b) **M1** particles of both gases are in constant, random motion and diffuse from a region of higher concentration to a region of lower concentration
- (b) **A1** the two gases diffuse toward each other through the air in the tube until they meet and react, forming solid ammonium chloride at that point, oe
- (b) Answer: **Ammonia and hydrogen chloride particles move randomly and diffuse from where they are concentrated toward where they are less concentrated, so they spread along the tube in both directions until they meet and react to form a solid ring.**
- (c) **M1** ammonia particles are lighter (have a smaller relative formula mass) than hydrogen chloride particles
- (c) **A1** so at the same temperature the ammonia particles move/diffuse faster and travel further before meeting the hydrogen chloride particles, meaning they meet nearer to end B, oe
- (c) Answer: **Ammonia particles are lighter than hydrogen chloride particles, so they diffuse faster and travel further along the tube in the same time, meaning the two gases meet closer to the hydrochloric acid end.**

Question 13

- (a) **M1** 24 / 40, ft from Q8(b)
- (a) **A1** x 100 = 60% cao
- (a) Answer: **60%**
- (b) **B1** 40% (100 - 60), ft from (a)
- (b) Answer: **40%**
- (c) **M1** 15 x 0.60, ft from (a)
- (c) **A1** 9 g cao
- (c) Answer: **9 g**

Question 14

- (a) **B1** True cao
- (a) Answer: **True**
- (b) **B1** False; relative formula mass is found using relative atomic masses (Ar values), not atomic numbers, oe
- (b) Answer: **False - relative formula mass uses relative atomic masses (Ar), not atomic numbers.**
- (c) **B1** True cao
- (c) Answer: **True**
- (d) **B1** False; mixtures can be present in any (variable) proportion, unlike compounds which have a fixed ratio, oe
- (d) Answer: **False - mixtures can be present in any proportion, unlike compounds, which have a fixed ratio.**

Question 15

- (a) **B1** 6 carbon atoms
- (a) **B1** 12 hydrogen atoms
- (a) **B1** 6 oxygen atoms
- (a) Answer: **6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms.**
- (b) **B1** 2 nitrogen atoms and 8 hydrogen atoms (from the 2 NH4 groups)
- (b) **B1** 1 sulfur atom and 4 oxygen atoms
- (b) Answer: **2 nitrogen atoms, 8 hydrogen atoms, 1 sulfur atom and 4 oxygen atoms.**

Question 16

- **B1** chemical bonds/bonding cao
- Answer: **Chemical bonds (bonding).**

Question 17

- **B1** no atoms are created or destroyed in a chemical reaction, so total mass of reactants = total mass of products, oe
- **M1** mass of oxygen = 44 - 12
- **A1** = 32 g cao
- Answer: **32 g**

Question 18

- **Level 1** (1-2): Basic, isolated statements about using a magnet or noting a colour/smell difference, with little or no reference to particle theory or separation methods.
- **Level 2** (3-4): A description of at least one valid test (e.g. using a magnet, or trying to separate the substances) with some correct reference to why the mixture and the compound behave differently, using some particle ideas.
- **Level 3** (5-6): A clear, logically linked explanation of at least two valid tests, correctly linking observations to the idea that a mixture retains the properties of its separate substances (so can be physically separated, e.g. iron is still magnetic) while a compound has entirely new properties (so cannot be separated by simple physical means, e.g. the iron is no longer magnetic).
- **Indicative content:**
  - In the mixture, the iron filings keep their own properties (e.g. still magnetic, still grey and metallic), because no chemical bonding has occurred between the iron and the sulfur.
  - A magnet can be used to pull the iron out of the mixture, because the iron particles are simply mixed in, not chemically joined to the sulfur.
  - In the compound iron sulfide, the iron and sulfur atoms are chemically bonded together, forming a new substance with different properties from either iron or sulfur.
  - A magnet will not attract iron sulfide, because the iron no longer exists as separate magnetic iron atoms; it has combined chemically with the sulfur.
  - The compound cannot be separated back into iron and sulfur by simple physical methods such as using a magnet or dissolving, because chemical bonds must be broken, which needs a chemical reaction, not a physical process.
  - The mixture can be present in variable proportions of iron and sulfur, whereas the compound iron sulfide always has iron and sulfur combined in one fixed ratio.