2.2 Atoms, Elements and Compounds: 1-hour Pack

Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Bronze is an alloy made from 88% copper and 12% tin by mass.

(a) State why bronze is a mixture and not a compound. **(2)**

(b) Calculate the mass of tin in a bronze statue with a total mass of 250 kg. **(2)**

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2 Classify each of the following substances as an element, a compound or a mixture.

(a) (i) oxygen gas, O_2 (ii) carbon dioxide, CO_2 (iii) air (iv) sodium chloride (table salt) (v) bronze (vi) sea water. Classify each as an element, a compound or a mixture. **(6)**

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3 A chemical formula shows how many atoms of each element are present in a substance.

(a) State the number of atoms of each element present in one molecule of water, H_2O. **(2)**

(b) State the number of atoms of each element present in one molecule of carbon dioxide, CO_2. **(2)**

(c) State the number of atoms of each element present in one formula unit of calcium carbonate, $CaCO_3$. **(3)**

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4 The relative formula mass (Mr) of a substance is found by adding together the relative atomic masses (Ar) of all the atoms shown in its formula. Use these Ar values: H = 1, C = 12, O = 16, Ca = 40.

(a) Calculate the relative formula mass (Mr) of water, H_2O. **(2)**

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(b) Calculate the relative formula mass (Mr) of carbon dioxide, CO_2. **(2)**

.....

(c) Calculate the relative formula mass (Mr) of calcium carbonate, $CaCO_3$. Show your working. **(3)**

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5 Magnesium metal burns in oxygen to form magnesium oxide.

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

(b) The unbalanced symbol equation for this reaction is: $Mg + O_2 \rightarrow MgO$. Balance this equation. **(2)**

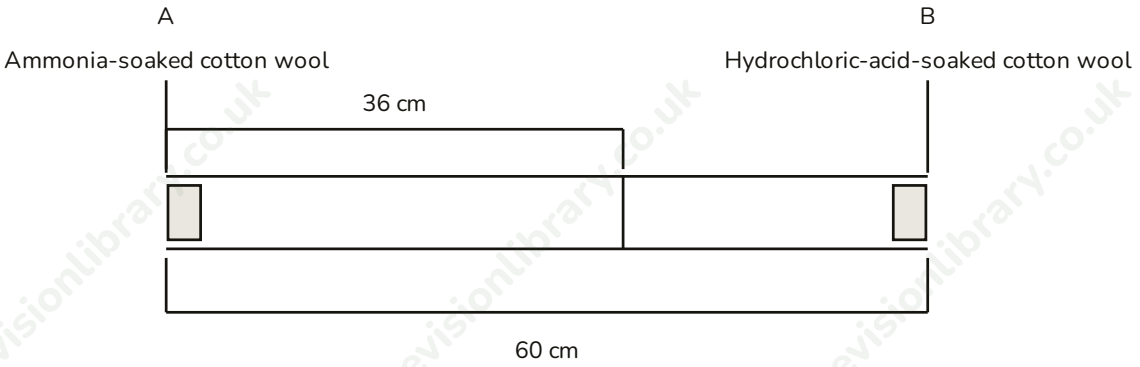
6 Carbon has several isotopes, including carbon-12 and carbon-14. Both have atomic number 6.

(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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7 Practical investigation: 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)**

(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)**

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8 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 a simple test, 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)

9 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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10 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)**

11 Oxygen (O), aluminium (Al) and calcium (Ca) have atomic number 8, 13 and 20, and mass number 16, 27 and 40, respectively. The periodic table arranges elements in order of atomic number, with metals on the left and centre and non-metals on the right.

(a) For oxygen (atomic number 8, mass number 16), state the number of protons, neutrons and electrons in a neutral atom. **(2)**

(b) For aluminium (atomic number 13, mass number 27), state the number of protons, neutrons and electrons in a neutral atom. **(2)**

(c) Calcium sits on the left-hand side of the periodic table. State whether calcium is a metal or a non-metal, and give one property you would expect it to have as a result. **(2)**

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Mark scheme · 2.2 Atoms, Elements and Compounds: 1-hour Pack

Question 1

(a) the copper and tin are not chemically joined (bonded) together oe — **B1**

(a) the proportions of copper and tin can be varied, and each metal keeps its own individual properties oe — **B1**

(a) Answer: **Bronze is a mixture because the copper and tin atoms are not chemically bonded together; the ratio of the two metals can be varied and each metal keeps its own properties.**

(b) 250 x 0.12 (or 250 x 12/100) — **M1**

(b) = 30 kg cao — **A1**

(b) Answer: **30 kg**

Question 2

(a) oxygen gas = element — **B1**

(a) carbon dioxide = compound — **B1**

(a) air = mixture — **B1**

(a) sodium chloride = compound — **B1**

(a) bronze = mixture — **B1**

(a) sea water = mixture — **B1**

(a) Answer: **Oxygen gas: element. Carbon dioxide: compound. Air: mixture. Sodium chloride: compound. Bronze: mixture. Sea water: mixture.**

Question 3

(a) 2 hydrogen atoms — **B1**

(a) 1 oxygen atom — **B1**

(a) Answer: **2 hydrogen atoms and 1 oxygen atom.**

(b) 1 carbon atom — **B1**

(b) 2 oxygen atoms — **B1**

(b) Answer: **1 carbon atom and 2 oxygen atoms.**

(c) 1 calcium atom — **B1**

(c) 1 carbon atom — **B1**

(c) 3 oxygen atoms — **B1**

(c) Answer: **1 calcium atom, 1 carbon atom and 3 oxygen atoms.**

Question 4

(a) (1 x 2) + 16 — **M1**

(a) = 18 cao — **A1**

(a) Answer: **Mr(H_2O) = 18**

(b) 12 + (16 x 2) — **M1**

(b) = 44 cao — **A1**

(b) Answer: **Mr(CO_2) = 44**

(c) identifies 1 Ca, 1 C and 3 O atoms from the formula — **M1**

(c) 40 + 12 + (16 x 3) — **M1**

(c) = 100 cao — **A1**

(c) Answer: **Mr($CaCO_3$) = 100**

Question 5

(a) magnesium + oxygen -> — **B1**

(a) -> magnesium oxide — **B1**

(a) Answer: **magnesium + oxygen -> magnesium oxide**

(b) 2Mg on the left and MgO adjusted to 2MgO oe working shown — **M1**

(b) 2Mg + O_2 -> 2MgO fully balanced cao — **A1**

(b) Answer: **2Mg + O_2 -> 2MgO**

Question 6

(a) both are atoms of carbon with the same number of protons (6), i.e. the same atomic number — **B1**

(a) they have different numbers of neutrons — **B1**

(a) this gives them different mass numbers (12 and 14) oe — **B1**

(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) = 8 cao (ft candidate's own atomic number of carbon from (a) if consistent) — **B1**

(b) Answer: **8 neutrons**

Question 7

(a) 36 / 60 — **M1**

(a) 0.6 cm/s cao — **A1**

(a) Answer: **0.6 cm/s**

(b) particles of both gases are in constant, random motion and diffuse from a region of higher concentration to a region of lower concentration — **M1**

(b) 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 — **A1**

(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) ammonia particles are lighter (have a smaller relative formula mass) than hydrogen chloride particles — **M1**

(c) 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 — **A1**

(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.**

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Question 8

Level 1 Basic, isolated statements about using a magnet or noting a colour/smell difference, with little or no reference to particle theory or separation methods. **1-2**

Level 2 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. **3-4**

Level 3 A clear, logically linked explanation of a valid test with observations for both samples, 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). **5-6**

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.

Question 9

B cao **B1**

Answer: **B) protons and electrons**

Question 10

(a) a substance made of only one type of atom, oe **B1**

(a) Answer: **A substance made of only one type of atom.**

(b) two or more different elements chemically joined (bonded) together in fixed proportions, oe **B1**

(b) Answer: **Two or more different elements chemically joined together in fixed proportions.**

(c) two or more substances that are not chemically joined together and can be present in any (variable) proportion, oe **B1**

(c) Answer: **Two or more substances not chemically joined together, which can be present in any proportion.**

Question 11

(a) 8 protons and 8 electrons (equal in a neutral atom, and equal to the atomic number) **M1**

(a) 8 neutrons, from mass number - atomic number = 16 - 8, cao **A1**

(a) Answer: **8 protons, 8 neutrons, 8 electrons.**

(b) 13 protons and 13 electrons (equal in a neutral atom, and equal to the atomic number) **M1**

(b) 14 neutrons, from mass number - atomic number = 27 - 13, cao **A1**

(b) Answer: **13 protons, 14 neutrons, 13 electrons.**

(c) calcium is a metal, because elements on the left/centre of the periodic table are metals **M1**

(c) gives a metal property such as it conducts electricity, is shiny/lustrous, or is malleable, oe **A1**

(c) Answer: **Calcium is a metal, since it is on the left-hand side of the periodic table; as a metal it would be expected to conduct electricity and be shiny/malleable.**

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