

**Atoms, Molecules and Stoichiometry – 2017**

1. 9701/11/O/N/17/1

Which formula represents the empirical formula of a compound?

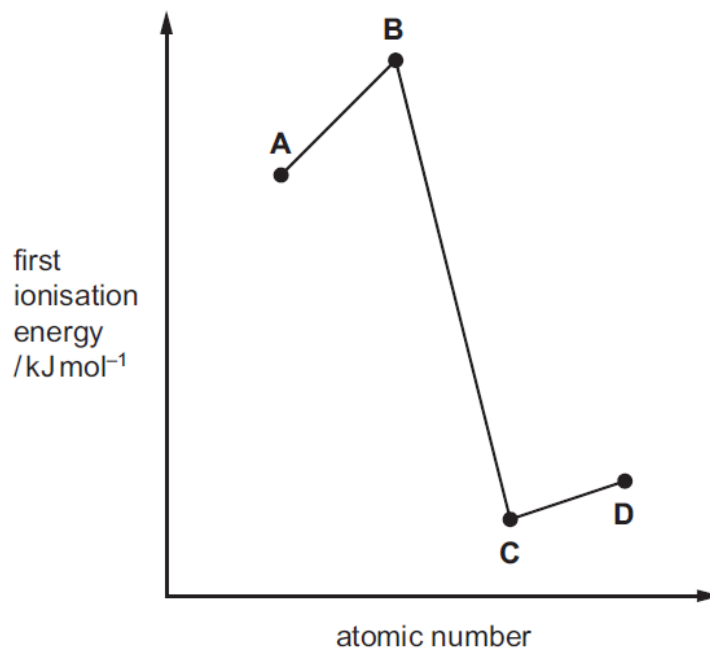
- A  $C_2H_4O$       B  $C_2H_4O_2$       C  $C_6H_{12}$       D  $H_2O_2$

2. 9701/11/O/N/17/2

The relative first ionisation energies of four elements with consecutive atomic numbers below 20 are shown on the graph.

One of the elements reacts with hydrogen to form a covalent compound with formula  $HX$ .

Which element could be X?



3. 9701/11/O/N/17/31

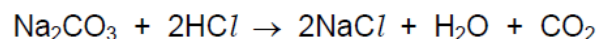
The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

- 1 first ionisation energy
- 2 heterolytic fission of a covalent bond
- 3 enthalpy change of atomisation

4. 9701/11/O/N/17/32

A student makes sodium chloride by reacting together 0.025 mol of sodium carbonate with an excess of 0.2 mol dm<sup>-3</sup> hydrochloric acid.



Which statements about the quantities of substance are correct?

- 1 600 cm<sup>3</sup> of carbon dioxide are produced at room temperature and pressure.
- 2 250 cm<sup>3</sup> of the hydrochloric acid are needed to exactly neutralise the sodium carbonate.
- 3 1.46 g of sodium chloride are produced.

5. 9701/12/O/N/17/1

In which pair do the atoms contain the same number of neutrons?

- A <sup>11</sup>B and <sup>12</sup>C
- B <sup>7</sup>Li and <sup>9</sup>Be
- C <sup>24</sup>Mg and <sup>28</sup>Si
- D <sup>14</sup>N and <sup>16</sup>O

6. 9701/12/O/N/17/2

Two hydrocarbons have the formulae  $C_WH_X$  and  $C_YH_Z$ . W, X, Y and Z represent different whole numbers.

$$\frac{W}{X} = \frac{Y}{Z}$$

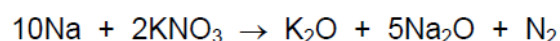
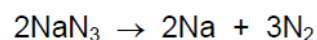
Which row is correct when comparing the two hydrocarbons?

	empirical formula	molecular formula	relative molecular mass
A	different	same	different
B	different	same	same
C	same	different	different
D	same	different	same

7. 9701/12/O/N/17/3

The airbags in cars contain sodium azide,  $NaN_3$ , and an excess of potassium nitrate,  $KNO_3$ .

In a car accident, the reactions shown occur, producing nitrogen. This causes the airbag to inflate rapidly.



How many moles of nitrogen gas are produced **in total** when 1 mol of sodium azide,  $NaN_3$ , decomposes in an airbag?

- A 1.5                      B 1.6                      C 3.2                      D 4.0

8. 9701/12/O/N/17/31

In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and are called flerovium, Fl, and livermorium, Lv.

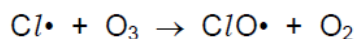
	Fl	Lv
proton number	114	116
nucleon number	289	292

From the information about atoms in the table, which statements are correct?

- 1 One atom of Lv has one more neutron than one atom of Fl.
- 2 One  $Fl^{2-}$  ion has the same number of electrons as one atom of Lv.
- 3 One  $Lv^+$  ion has the same number of electrons as one  $Fl^-$  ion.

9. 9701/12/O/N/17/32

The chlorine oxide free radical,  $ClO\cdot$ , is produced by the reaction between chlorine atoms and ozone.



Which features are present in the chlorine oxide free radical?

- 1 an odd number of electrons
- 2 a single covalent bond
- 3 a dative covalent bond from oxygen to chlorine

10. 9701/12/F/M/17/1

Which ion has the same electronic configuration as  $Cl^-$ ?

- A  $F^-$                       B  $P^+$                       C  $Sc^{3+}$                       D  $Si^{4+}$

11. 9701/12/F/M/17/2

Compounds J and K each contain 40% carbon by mass.

What could J and K be?

	J	K
A	a hexose, $C_6H_{12}O_6$	starch, $(C_6H_{10}O_5)_n$
B	a pentose, $C_5H_{10}O_5$	a hexose, $C_6H_{12}O_6$
C	a pentose, $C_5H_{10}O_5$	sucrose, $C_{12}H_{22}O_{11}$
D	starch, $(C_6H_{10}O_5)_n$	sucrose, $C_{12}H_{22}O_{11}$

12. 9701/12/F/M/17/3

Two moles of compound P were placed in a sealed container. The container was heated and P was partially decomposed to produce Q and R only. A dynamic equilibrium between P, Q and R was established.

At equilibrium  $x$  moles of R were present and the total number of moles present was  $\left(2 + \frac{x}{2}\right)$ .

What is the equation for this reversible reaction?

- A  $P \rightleftharpoons 2Q + R$   
 B  $2P \rightleftharpoons 2Q + R$   
 C  $2P \rightleftharpoons Q + R$   
 D  $2P \rightleftharpoons Q + 2R$

13. 9701/12/F/M/17/31

Nitrogen and phosphorus are both in Group 15 of the Periodic Table. Phosphorus forms a chloride with the formula  $PCl_5$  but nitrogen does not form  $NCI_5$ .

Which statements help to explain this?

- 1 Nitrogen's outer shell cannot contain more than eight electrons.
- 2 Nitrogen cannot have an oxidation state of +5.
- 3 Nitrogen is less electronegative than phosphorus.

14. 9701/11/M/J/17/2

The mass spectrum of a sample of lithium shows that it contains two isotopes,  ${}^6\text{Li}$  and  ${}^7\text{Li}$ .

The isotopic abundances are shown in the table.

isotope	isotopic abundance
${}^6\text{Li}$	7.42%
${}^7\text{Li}$	92.58%

What is the relative atomic mass of this sample of lithium, given to three significant figures?

- A** 6.07      **B** 6.50      **C** 6.90      **D** 6.93

15. 9701/11/M/J/17/3

A sports medal has a total surface area of  $150\text{cm}^2$ . It was evenly coated with silver by electrolysis. Its mass increased by  $0.216\text{g}$ .

How many atoms of silver were deposited per  $\text{cm}^2$  on the surface of the medal?

- A  $8.0 \times 10^{18}$       B  $1.8 \times 10^{19}$       C  $8.7 \times 10^{20}$       D  $1.2 \times 10^{21}$

16. 9701/11/M/J/17/4

Which property of an atom does **not** affect its first ionisation energy?

- A the atomic radius  
B the number of electron shells  
C the number of neutrons  
D the number of protons

17. 9701/11/M/J/17/6

The complete combustion of 2 moles of a straight chain alkane produces  $400\text{dm}^3$  of carbon dioxide measured at  $301\text{K}$  and  $1 \times 10^5\text{Pa}$ . Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the straight chain alkane?

- A  $\text{C}_8\text{H}_{18}$       B  $\text{C}_{16}\text{H}_{34}$       C  $\text{C}_{20}\text{H}_{42}$       D  $\text{C}_{40}\text{H}_{82}$

18. 9701/11/M/J/17/12

Why is the second ionisation energy of sodium larger than the second ionisation energy of magnesium?

- A The attraction between the nucleus and the outer electron is greater in  $\text{Na}^+$  than in  $\text{Mg}^+$ .
- B The nuclear charge of  $\text{Na}^+$  is greater than that of  $\text{Mg}^+$ .
- C The outer electron of  $\text{Na}^+$  is more shielded than the outer electron of  $\text{Mg}^+$ .
- D The outer electron of Na is in the same orbital as the outer electron of Mg.

19. 9701/11/M/J/17/31

Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge/mass ratio.

In an experiment, protons are deflected by an angle of  $+15^\circ$ . In another experiment under identical conditions, particle Y is deflected by an angle of  $-5^\circ$ .

What could be the composition of particle Y?

	protons	neutrons	electrons
1	1	2	2
2	3	3	5
3	4	5	1

20. 9701/12/M/J/17/1

In which species are the numbers of protons, neutrons and electrons **all** different?

- A  ${}^{19}_9\text{F}^-$
- B  ${}^{23}_{11}\text{Na}^+$
- C  ${}^{31}_{15}\text{P}$
- D  ${}^{32}_{16}\text{S}^{2-}$



21. 9701/12/M/J/17/2

Which would contain  $9.03 \times 10^{23}$  oxygen atoms?

- A 0.25 mol aluminium oxide
- B 0.75 mol sulfur dioxide
- C 1.5 mol sulfur trioxide
- D 3.0 mol water

22. 9701/12/M/J/17/3

In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate. Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.

What is the equation for this reaction?

- A  $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$
- B  $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$
- C  $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$
- D  $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

23. 9701/12/M/J/17/31

An isolated gaseous atom of element X has paired electrons in at least one of its 3d orbitals and has a filled 4s subshell.

What could be the identity of element X?

- 1 iron
- 2 gallium
- 3 copper

24. 9701/13/M/J/17/1

The ion  $Y^{3-}$  contains 18 electrons and has a mass number of 31.

How many protons and neutrons does  $Y^{3-}$  contain?

	protons	neutrons
<b>A</b>	15	16
<b>B</b>	15	18
<b>C</b>	18	13
<b>D</b>	21	10

25. 9701/13/M/J/17/2

A 0.216 g sample of an aluminium compound X reacts with an excess of water to produce a single hydrocarbon gas. This gas burns completely in  $O_2$  to form  $H_2O$  and  $CO_2$  only. The volume of  $CO_2$  at room temperature and pressure is  $108\text{ cm}^3$ .

What is the formula of X?

- A**  $Al_2C_3$       **B**  $Al_3C_2$       **C**  $Al_3C_4$       **D**  $Al_4C_3$

26. 9701/13/M/J/17/31

Which statements about the atoms  $^{23}\text{Na}$  and  $^{24}\text{Mg}$  are correct?

- 1 They have the same number of filled electron orbitals.
- 2 They have the same number of neutrons.
- 3 They are both reducing agents.