# Top of the Bench National Final 2021 Younger paper answers

Please make sure you add in your school name in full and the year group you are currently in. You have 30 minutes to complete the quiz. It has 2 sections and a total of 15 questions.

Section A is a short answer section and is worth 10 marks in total.
Section B is a longer answer section with calculations and is worth 16 marks in total.

You will require a calculator and periodic table.

Check your spelling only correctly spelled answers will be marked correct.

Good luck!

* Required

Name *

Name of School *

School Year *

## Section A: It's elemental

The answer to each of these questions is an element found on the Periodic table.

There are 10 questions in this section.

1. The Nobel Prize for Chemistry in 2019 was awarded for the development of batteries containing this element.

lithium

2. This element makes up the largest proportion of the air we breathe in.

nitrogen

3. The most reactive non-metallic element.

fluorine

4. Before the lamps were replaced with LEDs, this element was responsible for giving street lamps their orange glow.

sodium

5. This element glows when exposed to oxygen. Its name is derived from the Greek for ‘light bearer.’

phosphorus

6. This metal is used to make artificial joints as it is biocompatible and resists corrosion.

titanium

7. The surface of Mars appears red due to the oxide of this element.

iron

8. This metal melts in your hand.

gallium or caesium

9. Poisoning of hat makers by this element during the manufacture of hats led to the phrase ‘as mad as a hatter.’

mercury

10. Diamond and graphite are made from this element.

carbon

SECTION B: There are 5 questions in this section. Each question has multiple parts.

11. One of the first scientists to develop our understanding of atoms was a scientist called John Dalton. He believed that all elements were made up of small indivisible particles called atoms.

He drew symbols to represent different atoms. Some of the symbols he used are shown in Figure 1.

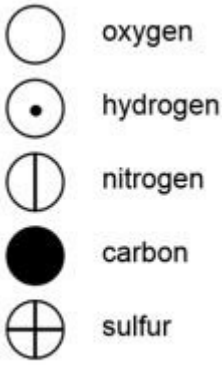
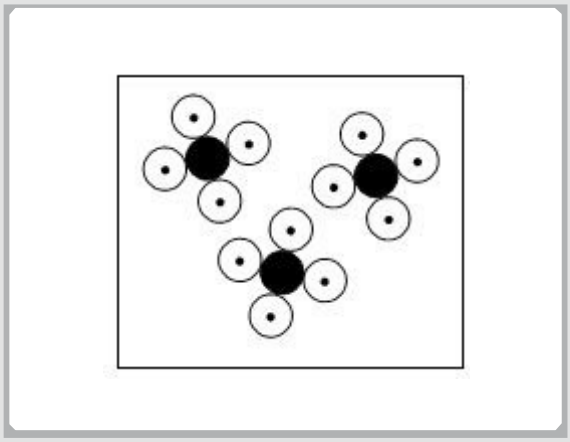


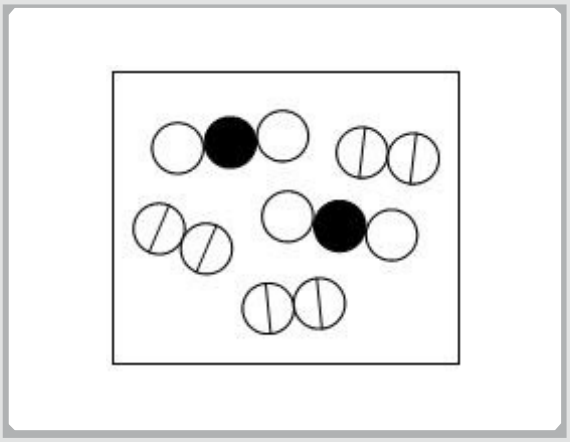

**Figure 1**

(a) (i) The diagrams below show some different combinations of these atoms. Select the diagram below that represents an element (1 mark)

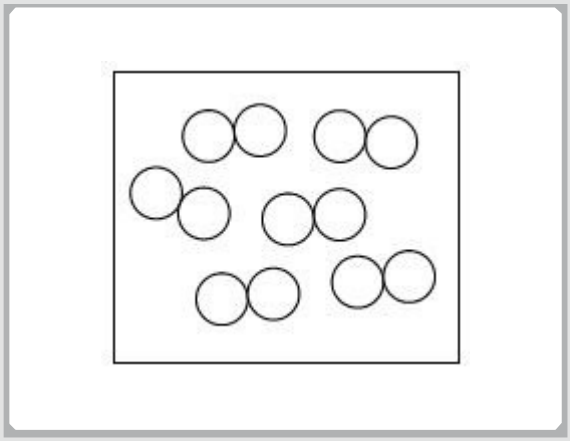
*Check all that apply.*



☐ Option 1



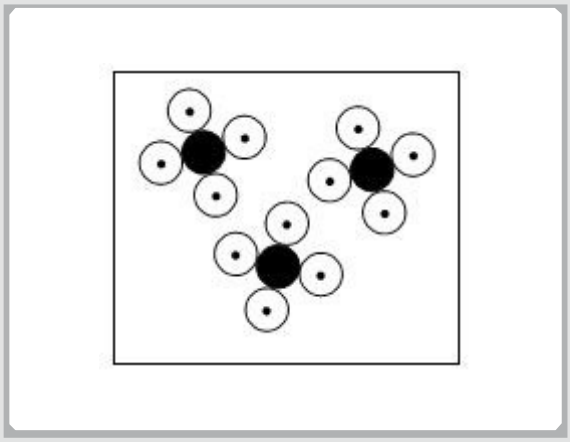
☐ Option 2



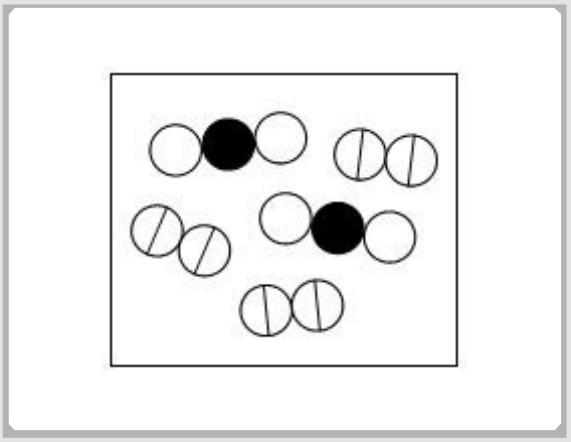
☒ Option 3

(a) (ii) The diagrams below show some different combinations of these atoms. Select the diagram below that represents a mixture (1 mark)

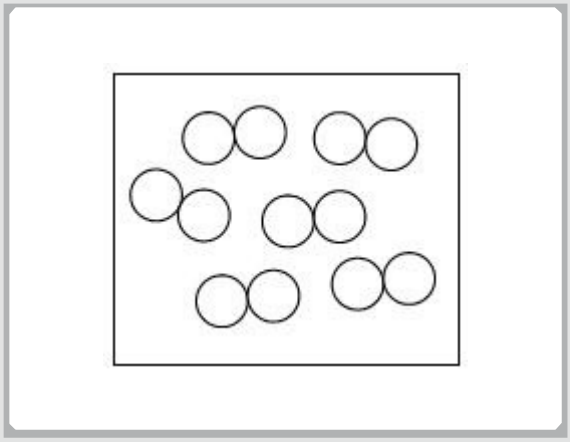
*Mark only one oval.*



( ) Option 1



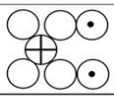
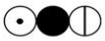
(X) Option 2



( ) Option 3

(b) In Table 1 Dalton's symbols have been used to draw some different chemical compounds.

**Table 1**

| Representation | Molecular formula | Name |
|---|---|---|
|  | $CO_2$ | *carbon dioxide* |
|  | A | B |
|  | C | D |
|  | E | F |
|  | G | H |
|  | I | J |

Complete Table 1 by using the symbols in Figure 1 to write the molecular formula of each compound and give its chemical name. Write your answer next to the corresponding letter below: you will not be penalised for being unable to subscript numbers. (5 marks)

A

$H_2O$

B

water

C

CO

D

carbon monoxide

E

$NH_3$

F

ammonia

G

$H_2SO_4$

H

sulfuric acid

I

HCN

J

hydrogen cycanide

12. A scientist collects some data to help him identify different elements.

The data collected is shown in Table 2.

| Element | Appearance | Melting point in °C | Boiling point in °C |
|---|---|---|---|
| A | Orange/brown | -7 | 58 |
| B | Colourless | -218 | -183 |
| C | Silver/grey | 1540 | 2890 |
| D | Silver/grey | 660 | 2450 |
| E | Silver/grey | 63 | 766 |
| F | Colourless | -248 | -246 |

**Table 2**

(a) (i) Identify the element(s) that are likely to be metals. (1 mark)

C, D and E (all needed for 1 mark)

(a) (ii) Describe a further test the scientist could do to prove that these elements are metals. (2 marks)

Examples

| Test | Result |
|---|---|
| Test to see if the element conducts electricity | Metals conduct electricity |
| Test to see if the element conducts heat | Metals are good conductors of heat |

1 mark - description of test  1 mark - indication of what a positive result looks like

(b) (i) Identify the element which is a liquid at room temperature. (1 mark)

A

(b) (iI) Explain how you can tell from the data that this element is a liquid at room temperature. (1 mark)

Room temperature is approximately 20°C which is above the melting point of A but below the boiling point

13. This question is about the Group 1 metals – the alkali metals.

(a) Group one metals react with water to produce the metal hydroxide and hydrogen gas.

(a) (i) Write a word equation for the reaction of lithium with water. (1 mark)

lithium + water → lithium hydroxide + hydrogen

(a) (ii) Describe a test a student could carry out to prove that hydrogen gas is produced. (2 mark)

Place a slit splint into the gas (1 mark)

Burns with a pop (1 mark)

(a) (iii) Use this reaction to suggest why the group one metals are called the Alkali metals. (1 mark)

The metal hydroxide products are alkaline / have a pH greater than 7

(b) Group one metals also react with non-metals such as chlorine.

Write a balanced symbol equation for the reaction of sodium with chlorine. (1 mark)

$2Na + Cl_2 \rightarrow 2NaCl$

1 mark - correct product NaCl  1 mark - correct formulae for reactants Na and $Cl_2$

1 mark balanced - can be awarded independent of above i.e. if correctly balanced but incorrect formulae

14. This question is about the Group 7 elements – the halogens.

We can use an element's position in the Periodic Table to give us information about the number of electrons in the atom.

As elements the halogens exist as diatomic molecules such as F2, Cl2, Br2 etc.

The total number of electrons in each molecule is equal to the number of electrons in a single atom multiplied by 2.

For example the total number of electrons in a molecule of fluorine $F_2$ is $9 \times 2 = 18$.

Table 3 below gives some information about the halogens.

| Element | Molecule | Total number of electrons in the molecule | Melting point in °C |
|---|---|---|---|
| fluorine | $F_2$ | 18 | – 220 |
| chlorine | $Cl_2$ | A | – 102 |
| bromine | $Br_2$ | B | – 7 |
| iodine | $I_2$ | C | 114 |
| astatine | $At_2$ | D | ? |

**Table 3**

(a) Complete Table 3 by writing in the total number of electrons in molecules of chlorine, bromine, iodine and astatine. Write your answer next to the corresponding letter below: (1 mark)

A

34

B

70

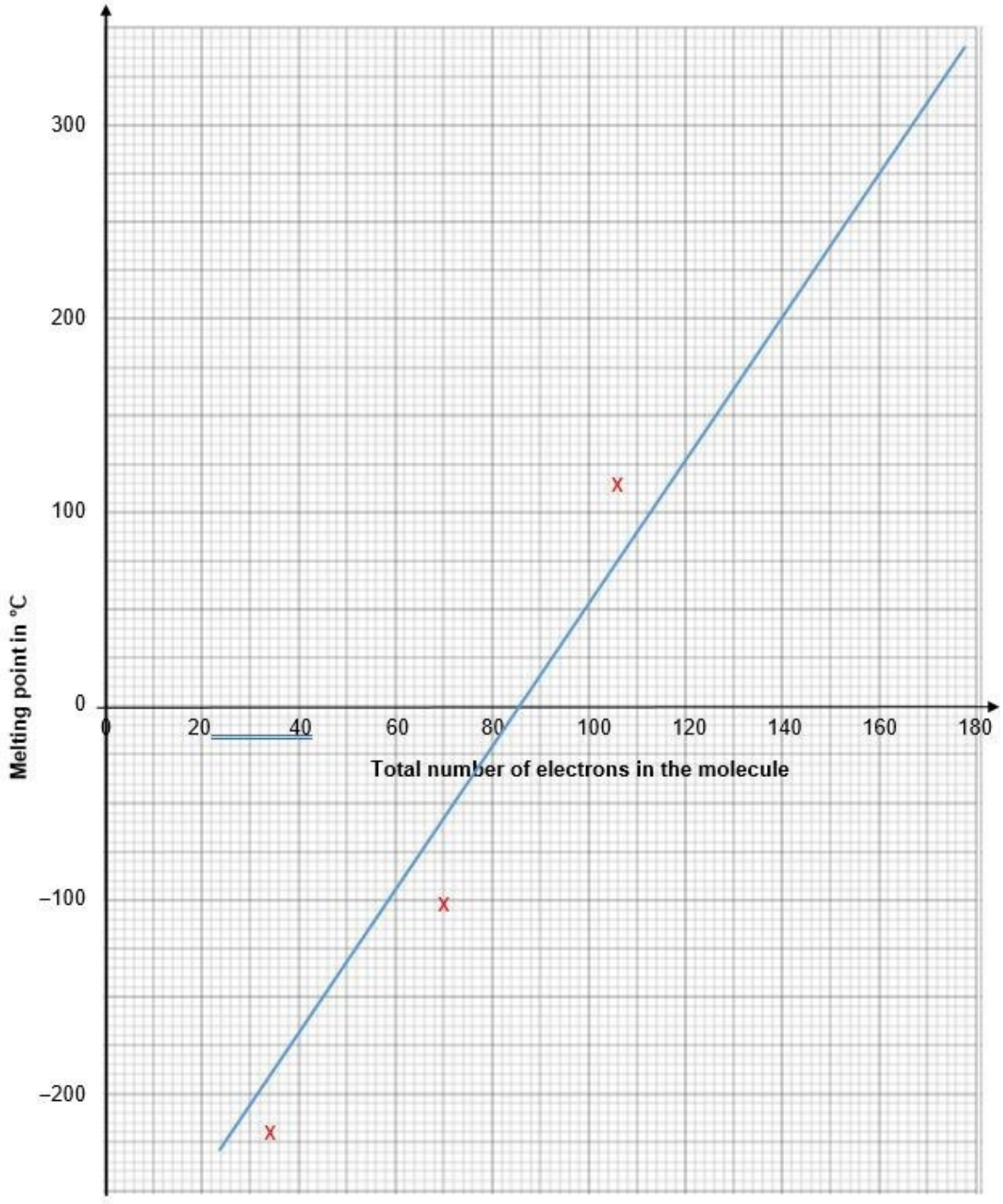
C

106

D

170

(b) The graph below is a plot of Total number of electrons in the molecule (x-axis) against melting point in °C (y-axis)




(b) (i) Use your graph to predict the melting point of astatine. (1 mark)

Correct value from their extrapolation (allow extrapolation of straight line of best fit)

(b) (ii) Describe the relationship between the total number of electrons in the molecule and the element's melting point. (1 mark)

The higher/larger/bigger the total number of electrons in the molecule the higher the melting point

or

The lower/smaller the total number of electrons in the molecule the lower the melting point

15. This question is about Group 0 – the Noble gases.

Helium, a Noble gas is used to fill party balloons because it is less dense than air.

(a) Calculate the mass of helium needed to fill a party balloon with a diameter of 50 cm. (3 marks)

You can assume that the balloon is a perfect sphere.

Show all your working.

Volume of a sphere = $4/3\ \pi r^3$

*where $\pi$ = 3.14 and r = radius of sphere*

Density of helium = 0.000164 g/cm$^3$

Density in g/cm$^3$ = $\frac{mass\ in\ g}{volume\ in\ cm^3}$

Radius of party balloon = **50** cm/2 = **25** cm (1 mark)

Volume of party balloon = 4/3 × 3.14 × (25 cm)$^3$ = 65416.67cm$^3$ (2dp) (1 mark)

Mass of helium = density × volume
= 0.000164 g × 65416.67 cm$^3$
= 10.73g (2 dp) (1 mark; allow error carried forward from incorrect volume)
(Correct answer with no working scores 2 marks)

(b) If 4 g of helium contains 6.02 × 10$^{23}$ individual helium atoms, calculate the number of helium atoms in the party balloon. (1 mark)

(6.02 × 10$^{23}$)/4 ×10.73 = 1.61 ×10$^{24}$ atoms

Allow errors carried forward from part (a)

