



WESTMINSTER SCHOOL
THE CHALLENGE 2021
CHEMISTRY

Thursday 29 April 2021
Time allowed: 30 minutes

Instructions to candidates:

This paper has **three** questions.

You should answer **all** questions

There are 33 marks available.

The marks for individual questions and parts of questions are shown in square brackets []. **Calculators are allowed.** Any data needed will be given in the questions.

Please write in black or blue ink.

Write your answers in the spaces provided.

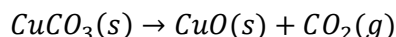
For examiner use only

Total Mark	
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C1. The following multiple-choice questions test a range of chemical principles. For each question, circle the letter corresponding to your chosen answer.

- a) Copper carbonate may be converted into copper oxide via the following equation.



What type of reaction is this?

- A** reduction
- B** neutralisation
- C** decomposition
- D** dehydration

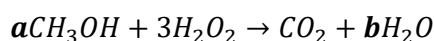
- b) A cleaning solution is used to remove limescale, CaCO_3 , from bathroom surfaces. When the solution is sprayed onto the limescale, effervescence (fizzing) occurs and the solid limescale begins to disappear. This chemical reaction is needed because the limescale cannot be removed with water alone.

Which of the following statements about this chemical reaction are correct?

1. the cleaning solution is acidic
2. the effervescence is caused by the release of hydrogen gas
3. the pH of the reacting solution will go down as the reaction proceeds

- A** 1 only
- B** 1 and 2 only
- C** 2 and 3 only
- D** 1 and 3 only
- E** None of the above combinations

- c) Methanol can be oxidised by hydrogen peroxide to produce carbon dioxide and water.



Balanced chemical equations must have the same number of each atom on both sides of the equation. What is the value of **b** when this equation is balanced?

- A** 2
- B** 4
- C** 5
- D** 10

d) Some experiments are carried out on three elements (**A**, **B** and **C**). Use the information below to answer the questions that follow.

- **A** reacts with hydrochloric acid to produce a colourless gas, but reacts very slowly with water.
- **B** does not react with the sulphate of **A**.
- **C** reacts rapidly with water to produce a colourless gas.

Which of the elements is the most reactive?

- A** **A**
- B** **B**
- C** **C**
- D** Not enough information available

e) Which one of the following elements would form an acidic oxide?

- A** copper
- B** calcium
- C** sulphur
- D** magnesium

[Total for C1: 5 marks]

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C2. This question is about the chemistry of pigments used in paints.



Naturally occurring compounds have been used for millennia to make colours for painting. Some similar compounds may often give rise to different colours depending on the conditions – for example, the acidity of the mixture.

The colour green can be made from a mineral called malachite but a very similar compound, called azurite, gives the colour blue.

a) The chemical formula of malachite may be represented as $Cu_2CO_3(OH)_x$ – in this question you will deduce the value of x in this formula.

(i) A sample of powdered malachite was added to sulphuric acid. Bubbles of a colourless gas were produced and a blue solution was formed. The gas was identified as carbon dioxide.

Suggest a chemical test that would allow you to show that the gas was carbon dioxide and give the positive result.

.....
.....
.....
..... [2]

(ii) Suggest, by name or chemical formula, the identity of **one** other product of the reaction of malachite with sulphuric acid.

..... [1]

(iii) Carbon dioxide is bubbled into some water containing Universal Indicator. Suggest the initial and final colour of the solution.

Initial

Final [2]

(iv) The same solution was then heated and the solution reverted to its original colour. Suggest why this may have happened.

.....
..... [1]

- b) The relative formula masses of chemical compounds can be calculated by summing the relative masses of their constituent elements.

Atom	H	C	O	S	Cu
Relative Mass	1	12	16	32	64

For example, the relative formula mass of $Cu(OH)_2$ is 98.

- (i) Calculate the relative formula masses of the following:

Water

Carbon dioxide

Sulphuric acid
(H_2SO_4) [3]

- (ii) The relative formula mass of malachite, $Cu_2CO_3(OH)_x$, is 222.
Deduce the value of x .

$$x = \dots\dots\dots [1]$$

- c) The formula for **azurite** is very similar to malachite but with different numbers of each atom present. Use the following information to answer the questions that follow.

- Azurite's formula is represented by $Cu_p(CO_3)_q(OH)_2$.
- The relative formula mass of azurite is 346.
- Azurite contains 55.5% Cu by mass.

- (i) Write an expression relating p and q using the relative masses of each atom and the relative formula mass.

[2]

- (ii) Given that 55.5% of the mass of azurite is due to Cu atoms, deduce the value of p .

$$p = \dots\dots\dots [2]$$

(iii) Deduce the value of q and hence state the chemical formula of azurite.

azurite formula..... [2]

(iv) Calculate the percentage by mass of oxygen in azurite.

O % by mass =[2]

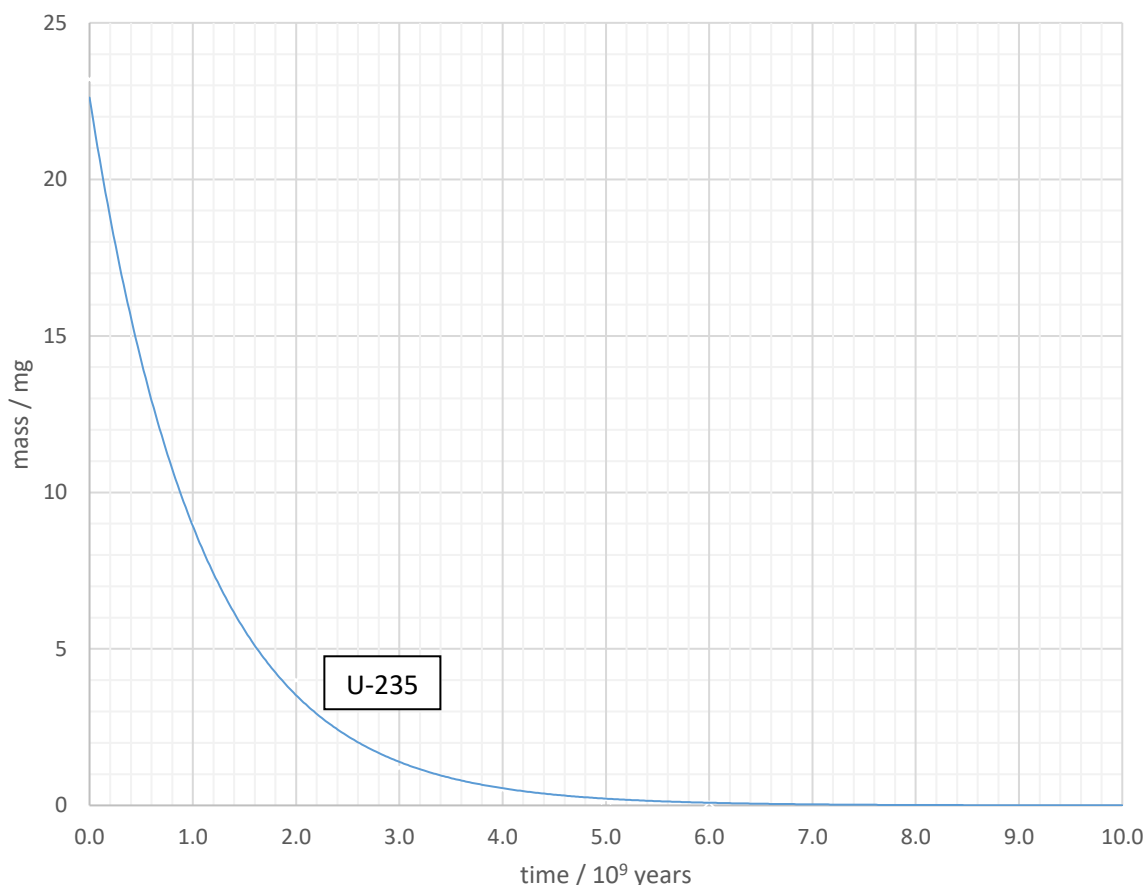
[Total for C2: 18 marks]

C3. This question is about one of the rarer elements on earth. You do not need to have studied its chemistry in order to answer this question.



Uranium is a radioactive element, which means it naturally breaks down over time. There are two common forms of uranium atoms (called isotopes) labelled, U-235 and U-238, which decay naturally into other elements. U-235 decays much faster than U-238. The rate of decay can be measured in terms of the radioactive half-life – the time taken for the mass of the sample to halve.

- a) The graph below shows how the amount of one of the isotopes of uranium (U-235) falls over time. [1mg = 0.001g; 10^9 years = 1,000,000,000 years]



- (i) **On the same axes above**, plot the data below to show how the mass of the other isotope (U-238) falls over time. Draw a line of best fit through your data.

Time / 10^9 years	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
mass of U-238 / mg	23.2	20.0	17.1	14.8	12.6	10.9	9.2	8.0	6.8	5.9	5.0

[3]

- (ii) The half-life of U-235 is 0.7×10^9 years. Using your graph, determine the half-life in years of **U-238**. You should show your working on the graph.

half-life of U-238 = [2]

- b) The following equation relates the number of radioactive atoms, N , remaining after a time t , to the number initially present, N_0 .

$$N = N_0 \times 2.72^{\frac{-0.69t}{t_{half}}} \quad \text{[Equation 1]}$$

t_{half} in this equation is the half-life of the isotope of uranium

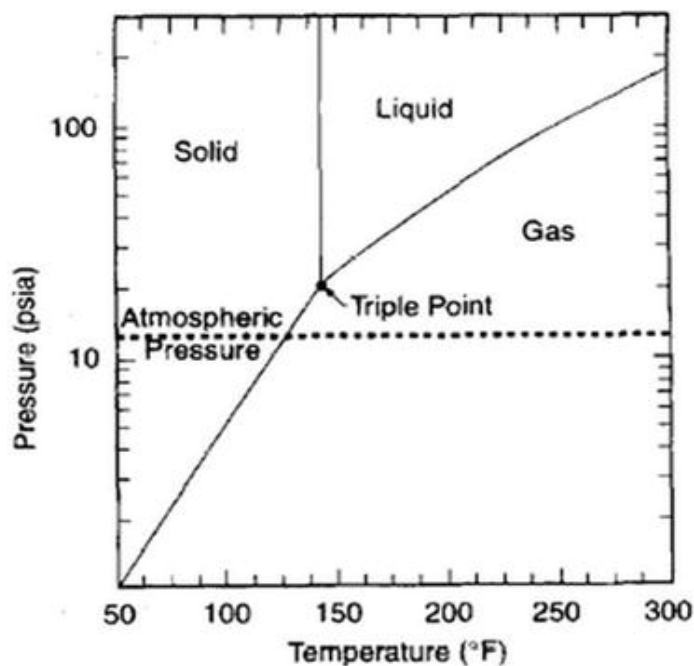
For the U-235 isotope (half-life= 0.7×10^9 years), calculate the number of atoms remaining after 5.6×10^9 years, the approximate age of the earth.

Give your answer as a percentage of the number of atoms originally present, N_0 , when the earth was formed.

[2]

- c) Uranium reacts with fluorine to produce a compound called uranium hexafluoride, UF_6 , which sublimes at fairly low temperatures.

The phase diagram for UF_6 is shown below. This allows chemists to see what phase (or state) a material exists in under certain conditions.



- (i) Define the term sublimation.

.....
..... [1]

- (ii) Suggest what conditions a chemist might use to make liquid UF_6 .

.....
..... [2]

[Total for C3: 10 marks]

END OF CHEMISTRY SECTION

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