N5 CHEMISTRY IN SOCIETY

HOMEWORK

MATERIALS, NUCLEAR, ANALYSIS

Radioactivity

1. Nuclear fusion takes place in the stars.
   (a) What is meant by nuclear fusion?
   (b) Why is it important?

2. The radiation that is all around is known as background radiation.
   Give a source of
   (a) artificial radiation,
   (b) natural radiation.

3. The nuclei of radioisotopes are unstable.
   (a) What is the cause of this instability?
   (b) What happens in the nucleus that results in a stable isotope?

4. $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + {}^{1}_{0}n$
   (a) Name this type of reaction.
   (b) Where do reactions of this type occur naturally?

5. Copy and complete the following table.

Radiation	Alpha	Beta	Gamma
Symbol			
Mass			
Charge			

6. Alpha, beta and gamma radiation have different penetrating properties.

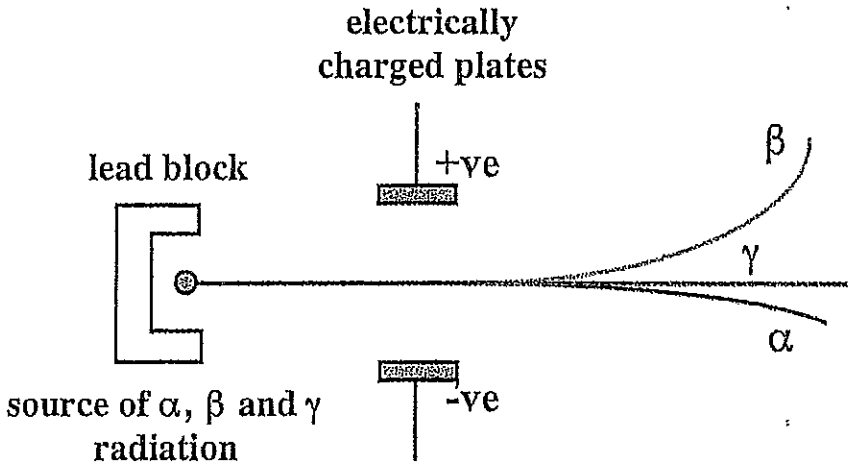
Name the type of radiation that is

(a) able to penetrate 5 cm of lead,

(b) stopped by a sheet of paper,

(c) stopped by a sheet of aluminium.

7. The following experiment was carried out using a radioisotope that emitted alpha, beta and gamma radiation.



(a) Why is the radioisotope surrounded by a thick lead block?

(b) Explain the paths taken by the **three** different types of radiation.

Nuclear equations

1. $^{225}_{88}Ra \rightarrow {}^{225}_{89}Ac + y$

   $^{217}_{85}At \rightarrow {}^{213}_{83}Bi + z$

   State the mass and charge of each of the particles **y** and **z**, and identify them.

2. Identify the isotope that is formed when
   (a) sodium-24 emits beta particles,
   (b) plutonium-242 emits alpha particles.

3. Write a nuclear equation for
   (a) α-decay of $^{210}_{84}Po$,
   (b) β-decay of tritium $^{3}_{1}H$,
   (c) α-decay of $^{226}_{88}Ra$,
   (d) β-decay of $^{90}_{38}Sr$.

4. (a) Write a nuclear equation to show what happens when ^{232}Th undergoes α-emission.
   (b) Show, by calculation, that the neutron to proton ratio has increased.

5. $^{27}_{13}Al$ can absorb an alpha particle with the emission of a neutron, forming a product **Y**.
   Write a nuclear equation to illustrate this reaction and identify **Y**.

6. Complete each of the following nuclear equations and identify **R** and **S**.

(a) $^{6}_{3}\text{Li} + {}^{1}_{0}\text{n} \rightarrow {}^{3}_{1}\text{H} + \mathbf{R}$

(b) $^{238}_{92}\text{U} + {}^{4}_{2}\text{He} \rightarrow {}^{239}_{94}\text{Pu} + 3\mathbf{S}$

7. State the mass and charge of each of the particles **x** and **y**, and identify them.

(a) $^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + \mathbf{x}$

(b) $^{6}_{3}\text{Li} + \mathbf{y} \rightarrow {}^{3}_{1}\text{H} + {}^{4}_{2}\text{He}$

8. (a) $^{10}_{5}\text{B} + {}^{1}_{0}\text{n} \rightarrow {}^{p}_{q}\mathbf{X} + {}^{4}_{2}\text{He}$

Write values for **p** and **q** and identify element **X**.

(b) $^{a}_{b}\mathbf{Y} + {}^{1}_{0}\text{n} \rightarrow {}^{24}_{11}\text{Na}$

Write values for **a** and **b** and identify element **Y**.

9. What is the source of ^{206}Pb, if it is formed by β-emission, followed by α-emission?

10. **P** is a radioisotope which undergoes transitions as follows.

$$\mathbf{P} \xrightarrow{\beta\text{-emission}} \mathbf{Q} \xrightarrow{\beta\text{-emission}} \mathbf{R} \xrightarrow{\alpha\text{-emission}} \mathbf{S}$$

If the atomic number of **P** is 88, and its mass number is 228, what is the atomic number and mass number for isotope S?

11. Plutonium-242 is a radioactive isotope that decays to form a stable isotope $^{b}_{a}\mathbf{X}$ by the following sequence of emissions.

α, α, β, β, α

Write values for **a** and **b** and identify element **X**.

Half-life

1. For each of the following pairs, state whether or not both species have the same half-life.
   (a) 1 g ^{212}Pb and 100 g ^{212}Pb
   (b) 1 g ^{212}Pb and 1 g $^{212}Pb^{2+}$
   (c) 1 mol ^{210}Pb and 1 mol ^{212}Pb
   (d) 1 mol ^{210}Pb and 1 mol ^{212}PbO
   (e) 1 mol of solid ^{210}Pb and 1 mol of molten ^{210}Pb

2. Samples of radium oxide and radium sulphate both contain the same radioisotope.
   Why does a 1 g sample of the oxide show a different intensity of radiation from the sulphate?

3. ^{24}Na is a radioactive isotope of sodium with a half-life of 15 hours.
   A sample of ^{24}Na has a mass of 200 g.
   (a) What is meant by half-life?
   (b) What will be the remaining mass of the original sample after 120 hours?

4. Polonium-218 is an alpha emitting radioisotope.
   After 6 minutes the mass of the radioisotope was found to be one eighth of the original.
   What is the half-life of the radioisotope?

5. The initial radioactivity from a sample of actinium chloride is 120 counts/minute.
   If the half-life of actinium is 6 hours, how long will it take for the sample of the chloride to reach a reading of 15 counts/minute?

6. The rate of alpha emission from a 48 day old sample of a radioactive isotope was found to be a quarter of that of the original sample.

   What is the half-life of the sample?

7. A radioisotope used in a hospital has a half-life of 1.5 hours.
   It has a count rate of 8000 counts min^{-1} at 9.00 a.m.

   (a) What would the count rate be at 1.30 p.m. on the same day?

   (b) An aqueous solution of a compound containing the radioisotope was prepared.
   What effect would this have on the half-life?

8. $^{210}_{84}Po$, which has a half-life of 140 days, decays by α-emission to give a stable isotope.

   What fraction of the sample will remain unchanged after 280 days?

9. After 15 days a sample contained 0.1 g of radioactive bismuth, half-life 5 days.

   What was the mass of the original sample?

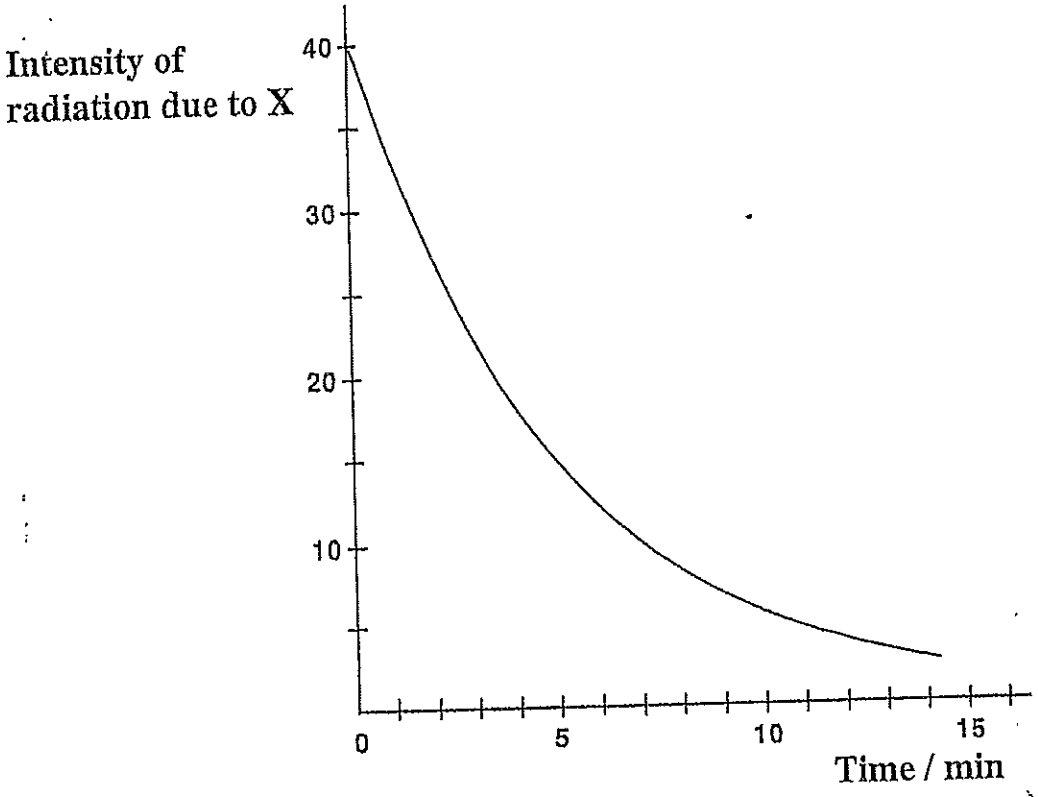
10. The isotope of iodine-131 is radioactive and is manufactured for medicinal use.

    If, 24 days after manufacture, only 32.75 g of an original one mole sample of radioactive iodine remains, calculate the half-life of the isotope.

11. The radioactive isotope $^{210}_{84}Po$ decays to $^{206}_{82}Pb$, which is stable.

    Calculate the mass of lead that would be formed from 1 mol of $^{210}_{84}Po$ after two half-lives.

12. A radioisotope **X** decays to give a stable product. The decay curve is shown.



(a) What is the half-life of isotope **X**?

(b) The half-life of a radioisotope **Y** is 6 min.

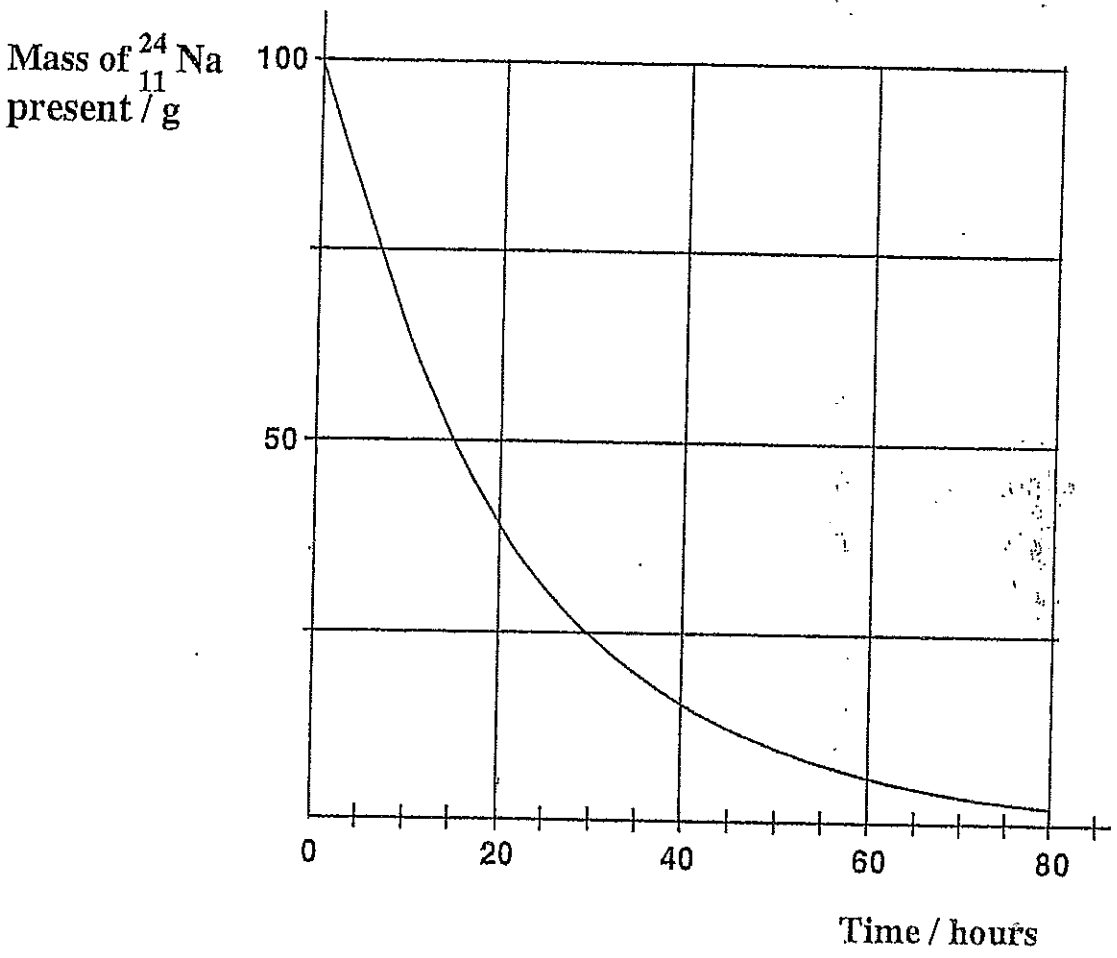
Copy the graph (no graph paper required), and add a dotted line to show the decay curve for isotope **Y**, assuming that it starts at the same intensity of radiation as isotope **X**.

13. The half-life of a radioisotope is 8 hours.

(a) Draw a graph (no graph paper required) to show the variation with time of the intensity of radiation due to the decay of a 10 g sample that has an intensity of 40 counts/minute.

(b) Using the same scale and axes, add a dotted line to show what the graph would be for a 5 g sample.

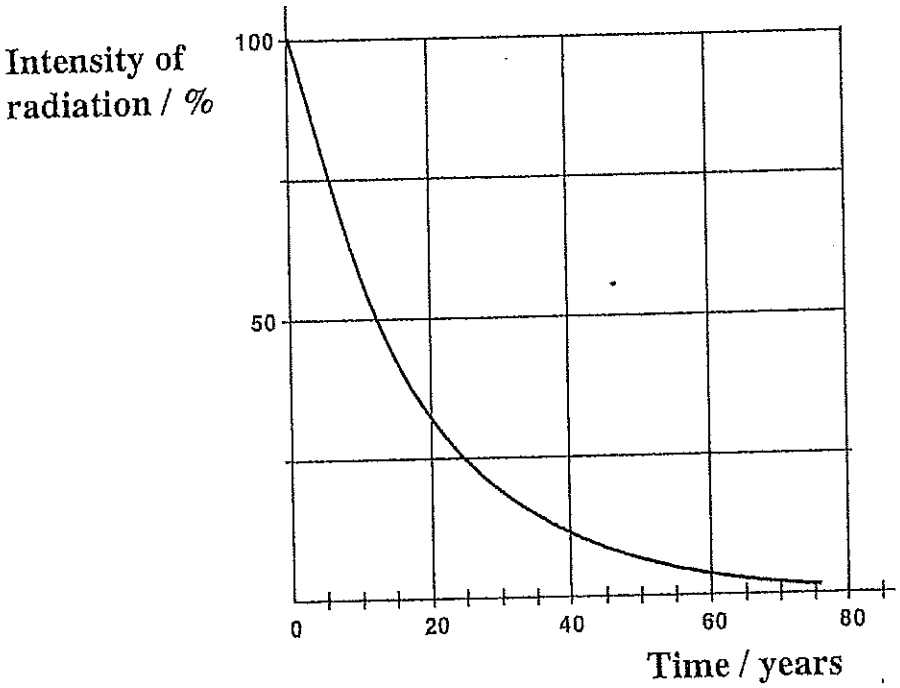
14. An 8 g sample of $^{24}_{11}Na$ undergoes β-decay to form $^{24}_{12}Mg$ as shown in the graph below.



(a) From the graph, what is the half-life of $^{24}_{11}Na$?

(b) What mass of product would be formed from the sample after 45 hours?

15. The decay curve for the radioisotope tritium, $^{3}_{1}H$, is shown below.



(a) (i) From the graph, what is the half-life of tritium?

(ii) Calculate the time taken for the radioactivity to fall to ⅛th of its original value.

(b) If the temperature of the tritium sample is increased, how would this affect its rate of decay?

16. The radio-isotope $^{131}_{53}I$ is used in hospitals. It has a half-life of 8 days and decays to give a stable product.

A bag of hospital linen contaminated with iodine $^{131}_{53}I$ was found to give a count rate of 320 counts s^{-1}.

(a) Using graph paper, draw a graph to show how the count rate of the linen will change with time.

(b) Hospitals are not allowed to dispose of material contaminated with $^{131}_{53}I$ until the count rate has fallen to 30 counts s^{-1}.

Use your graph to determine how long the bag of linen must be stored before disposal.

Chemical analysis

1. What is the difference between qualitative and quantitative analysis?

2. Flame tests can be used to identify the presence of particular metals in solutions of metal ions.
   (a) What is the characteristic flame colour of each of the following metal ions?
      (i) copper
      (ii) potassium
      (iii) sodium
   (b) Is a flame test an example of qualitative or quantitative analysis?

3. Litmus paper turns red in acid and blue in alkali.
   (a) Why is the use of litmus paper an example of qualitative analysis?
   (b) Why is pH measurement an example of quantitative analysis?

4. A sample of water is taken from a factory effluent.
   What is the concentration of H^+ (aq) ions in the water if 25 cm^3 of sodium hydroxide solution (concentration 0.002 mol l^{-1}) is neutralised by34.5 cm^3 of the sample?

5. When silver nitrate solution is added to 25 cm^3 of a water sample containing chloride ions, 2.87 g of silver chloride is formed.

   Ag^+ (aq) + Cl^- (aq) → AgCl (s)

   (a) (i) Calculate the number of moles of silver chloride that is formed.
      (ii) Calculate the concentration of chloride ions in the sample.
   (b) Is this an example of qualitative or quantitative analysis?

Graphs

1. When copper(II) sulphate solution is placed in a beam of light, some light is absorbed and some passes through.
The results of an investigation are shown below.

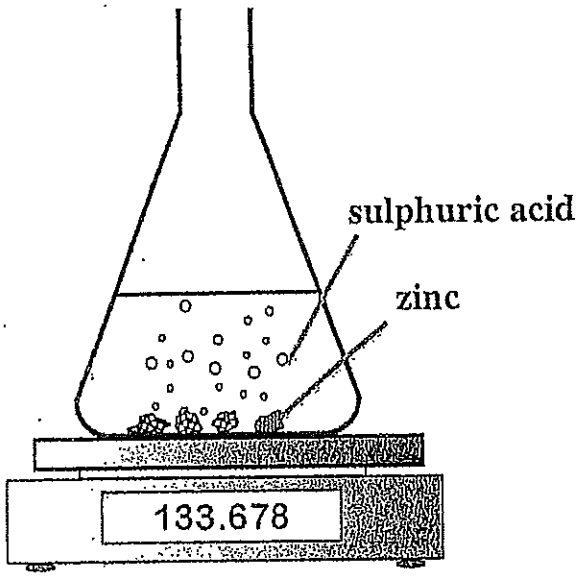
Concentration of $CuSO_4$ /moles per litre	0.05	0.2	0.4	0.6	0.8	1.0
Light passing through / %	74.0	29.0	11.0	5.0	3.0	2.0

(a) Draw a **line graph** to show these results.

(b) State the relationship between the amount of light passing through and the concentration of the copper(II) sulphate solution.

(c) Use your graph to estimate the concentration of a copper(II) sulphate solution that allows 50% of the light to pass through.

2. A student added lumps of zinc to dilute sulphuric acid. The mass of the flask and contents were noted every two minutes.



Time / min	Total mass loss / mg
0	0
2	130
4	210
6	260
8	300
10	330
12	330

(a) Why was there a loss of mass from the flask?

(b) Draw a **line graph** of loss of mass against time.

(c) Use your graph to find the total mass loss after 2.5 min.

3. Sea water contains dissolved oxygen

The table shows the relationship between the temperature of the water and the amount of dissolved oxygen.

Temperature of water / °C	0	20	40	60	70	80
Concentration of dissolved oxygen / grams in each cubic metre	69.4	43.4	30.8	22.7	18.6	13.8

(a) Draw a **line graph** to show these results.

(b) The average temperature of the seas around Scotland is approximately 9 °C.

Use your graph to find the concentration of oxygen available at this temperature.

(c) Use your graph to find the temperature of the water that contains 25 g of dissolved oxygen in each cubic metre.

4. The alkanes are a family of hydrocarbons each with a different number of carbon atoms per molecule.

The table shows the boiling points for each of the first five members.

Alkane	**Number of carbon atoms per molecule**	**Boiling point / °C**
A	1	-162
B	2	-89
C	3	-42
D	4	-1
E	5	36

(a) Draw a **bar graph** to show this information.

(b) Identify the alkanes shown in the table that are gases at

(i) -50 °C,

(ii) 10 °C.

5. The alkynes are a family of hydrocarbons each with a different number of carbon atoms per molecule.

The table shows the formula mass for each of the first five members.

Number of carbon atoms per molecule	Formula mass
2	26
3	40
4	54
5	68
6	82

(a) Draw a **bar graph** to show this information.

(b) Using either the information in the table or your bar graph, state the formula mass of the alkyne with 8 carbon atoms per molecule.

4. The concentration of sodium hypochlorite, NaOCl (aq), in a bleach can be found by adding an excess of dilute hydrochloric acid to a measured sample of the bleach. The acid reacts with the sodium hypochlorite and the volume of chlorine given off is measured.

$$NaOCl\,(aq) + 2HCl\,(aq) \rightarrow NaCl\,(aq) + H_2O\,(l) + Cl_2\,(g)$$

In an investigation of three different household bleaches, the following results were obtained.

Bleach	Volume of bleach used /cm^3	Volume of chlorine produced / cm^3
A	6	100
B	9	150
C	4	90

Find, **by calculation**, which bleach contains most sodium hypochlorite per litre.

5. Refer to page 8 of the Data Booklet.

For each of the compounds shown, decide if 5 g will dissolve in 1 litre of water at room temperature.
Use one of the following letters for your answer.

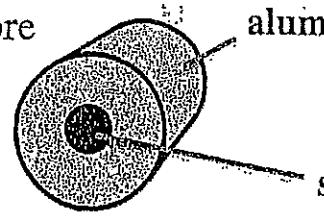
X All the solid will dissolve.
Y Some of the solid will **not** dissolve.
Z Not enough information is given to decide.

(a) calcium oxide
(b) lead(II) iodide
(c) potassium chloride

6. The uses of metals are related to their properties.

Metal	Density (g/cm^3)	Relative strength	Relative electrical conductivity
Aluminium	2.7	1.0	3.8
Steel	7.9	4.0	1.0
Copper	8.9	2.5	5.9

Overhead electricity cables have a steel core surrounded by an aluminium sheath.



Using information from the table, suggest
(a) an advantage of using aluminum rather than copper for the cable,
(b) why the cables have a steel core.

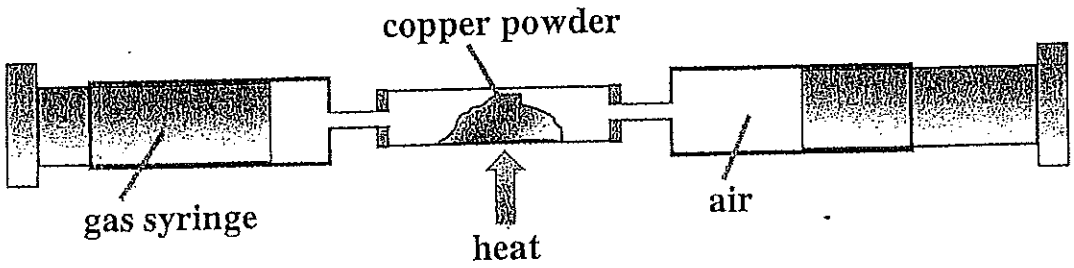
7. An electric current was passed through different solutions. The results are shown in the table.

Solution	Positive electrode product	Negative electrode product
hydrochloric acid	chlorine	hydrogen
potassium chloride	chlorine	hydrogen
sulphuric acid	oxygen	hydrogen
sodium nitrate	oxygen	hydrogen
nitric acid	oxygen	hydrogen
silver nitrate	oxygen	silver
potassium sulphate	oxygen	hydrogen

(a) From the results, suggest a general statement that can be made about acids.

(b) From the results, predict the product at the positive and negative electrodes when each of the following solutions is used used.
(i) sodium chloride
(ii) potassium nitrate

8. The percentage of oxygen in the air can be determined by passing air is over heated copper.



The copper powder reacts with the oxygen of the air to form copper(II) oxide.

A student obtained the following results.

Volume of air at start of experiment = 80 cm^3

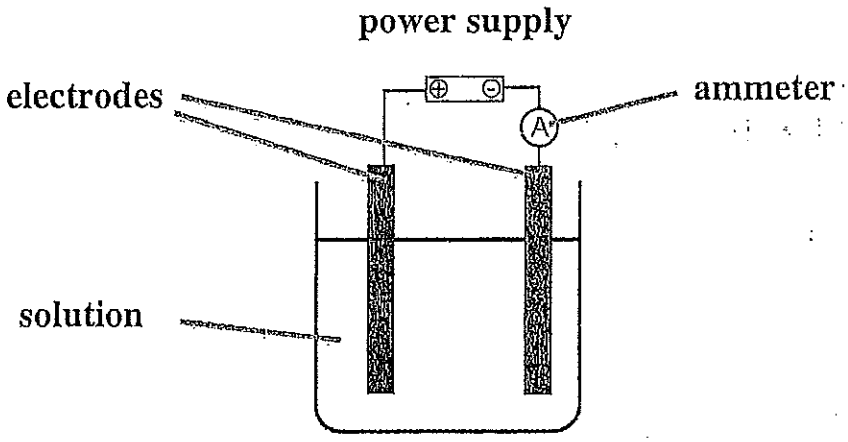
Volume of gas at end of experiment = 64.4 cm^3

(a) Suggest a reason why the air is passed backwards and forwards over the heated copper.

(b) Calculate the percentage of oxygen in the sample of air.

(c) In a second experiment using fresh copper, the percentage of oxygen in the sample of air was found to be lower.
Suggest a reason for this result.

9. The ability of different substances to conduct electricity when dissolved in water was investigated by a student.



Here are the results.

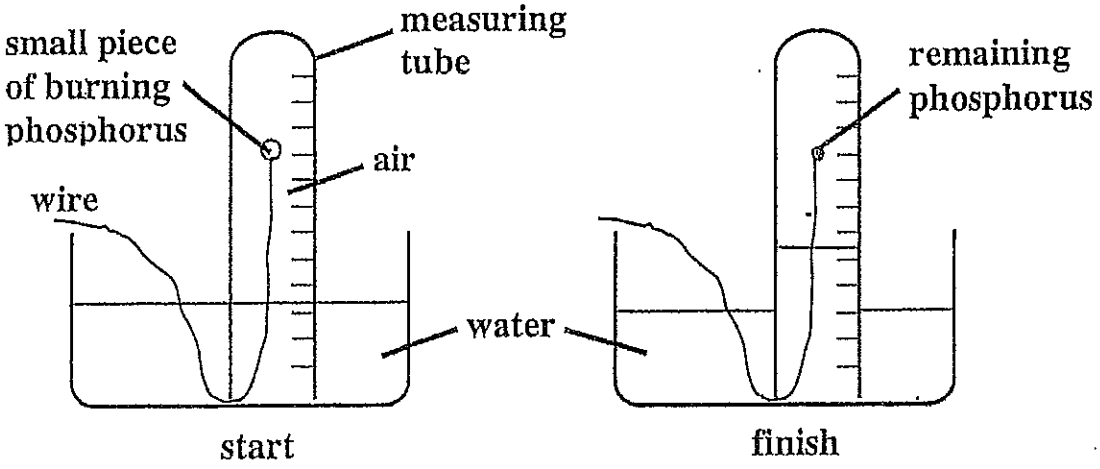
Substance	Concentration of solution / mol l^{-1}	Current /mA
sodium chloride	0.005	21
sodium chloride	0.002	11
sodium chloride	0.001	7
hydrochloric acid	0.005	62
hydrochloric acid	0.002	27
hydrochloric acid	0.001	20
sodium hydroxide	0.005	32
sodium hydroxide	0.002	15
sodium hydroxide	0.001	11

(a) Identify **two** variables that must be kept constant to make the investigation fair.

(b) From the results, state the effect of changing concentration on the ability of a substance to conduct electricity when dissolved in water.

(c) Arrange the three substances in order of their ability to conduct electricity when dissolved in water. (Put the best conductor first.)

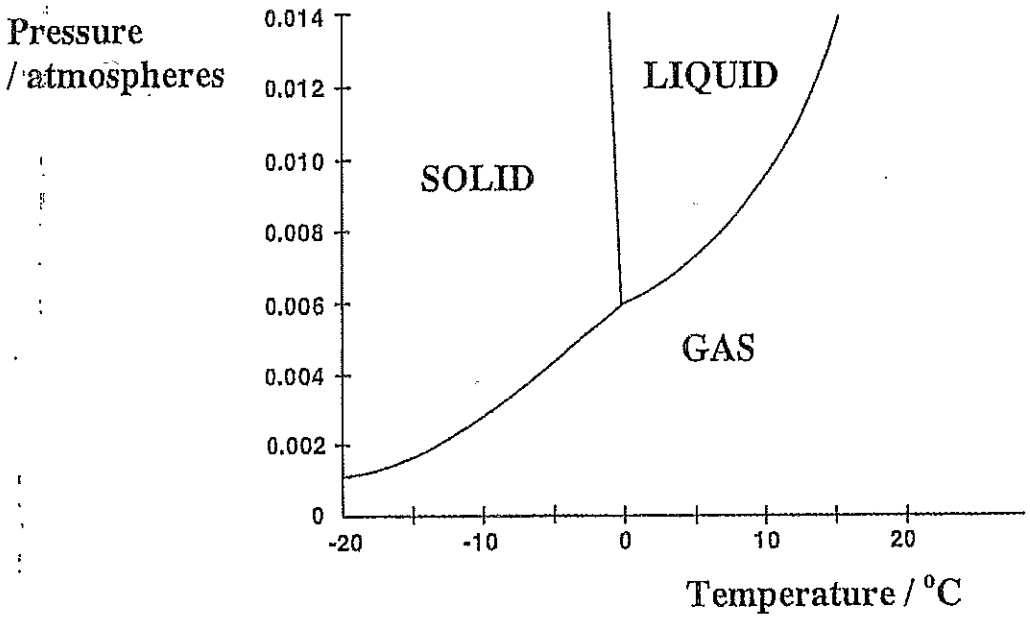
10. White phosphorus readily catches fire in air.
The following diagrams show this reaction.



(a) What would have been the effect on the final water level inside the tube, if a larger piece of phosphorus had been used?

(b) Explain your answer.

11. Water can exist in three different states: solid, liquid and gas.
The state depends on temperature and pressure.
The diagram below shows these relationships.



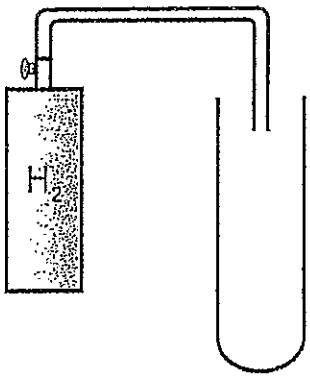
(a) In which state would water exist at 15 °C and 0.007 atmospheres?

(b) Solid water at 0.004 atmospheres is allowed to warm up.
The pressure is kept constant.
At what temperature would the solid water change into a gas?

Design and plan

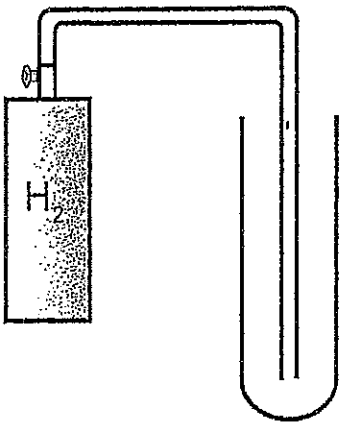
1. Hydrogen is less dense than air.
   Identify the most suitable arrangement for collecting a sample of hydrogen.

A



B

C



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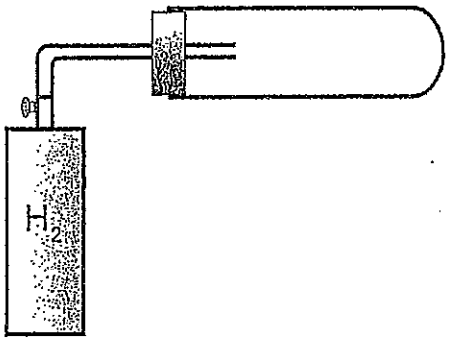

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