Student number: …….

Hornsby Girls' High School

2018
Preliminary Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 75 minutes
- Write using blue or black pen
- Draw graphs, diagrams and tables using a pencil
- Board-approved calculators may be used
- A Periodic Table is provided
- Write your student number at the top of each page
- Attempt all questions
- Marks are as indicated in brackets

Total marks – 50

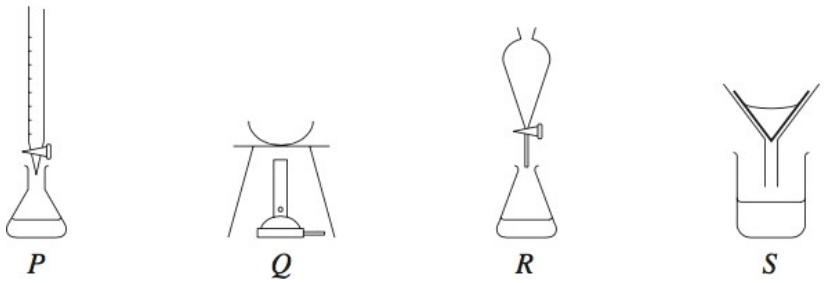
- Section I - Multiple Choice 6 marks
- Section II – Written Response 44 marks

Section I

Multiple choice questions (6 marks)

Circle your answer.

1 Which of the following equipment could be used to determine the mass of *dissolved* solids in a sample of muddy river water?



A. *P* and *Q*

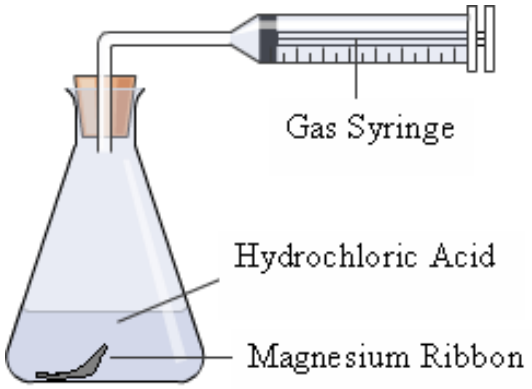
B. *Q* and *S*

C. *R* and *S*

D. *P* and *R*

2 When different lengths of magnesium ribbon are added to a 1.0 mol L^{-1} acid solution, hydrogen gas is produced. An experiment was set up as shown in the diagram and sufficient acid was added to the flask to ensure all the magnesium ribbon could react.

The hydrogen gas produced pushed the syringe plunger to the right.



For this experiment, identify the independent variable (IV) and dependent variable (DV).

A. IV: volume of hydrogen gas, DV: time

B. IV: concentration of acid, DV: mass of magnesium ribbon

C. IV: time, DV: volume of dilute acid

D. IV: length of magnesium ribbon, DV: volume of hydrogen gas

3 Ionisation energy is the energy required in kJ mol^{-1} for an electron to be removed from an atom.

The higher the ionisation energy, the more difficult it is to remove the electron.

The table below shows the ionisation energies for element X. Identify the element.

Ionisation energy number	1st	2nd	3rd	4th	5th	6th	7th
Ionisation energy in kJ mol^{-1}	577	1816	2745	11577	14842	18379	23326

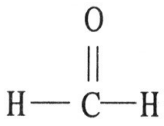
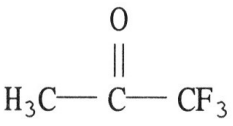
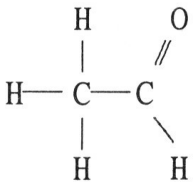
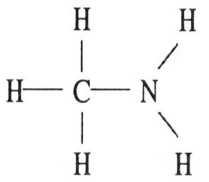
A. Potassium

B. Calcium

C. Aluminium

D. Germanium

4 Below are four different molecules. In a pure sample of each molecule, which one of the following substances will have hydrogen bonding as one of its intermolecular forces?

Molecule P	***Molecule Q***	***Molecule R***	***Molecule S***
			

A. Molecule *P*

B. Molecule *Q*

C. Molecule *R*

D. Molecule *S*

5 The table below contains data for a range of common metals.

Which element remains a liquid over the greatest temperature range?

Metal	***Mg***	***Fe***	***Cu***	***Ag***	***Au***
Z	12	26	29	47	79
A	24.31	55.85	63.55	107.9	197.0
Melting point (℃)	650	1538	1084	962	1064
Boiling point (℃)	1090	2862	2562	2162	2836

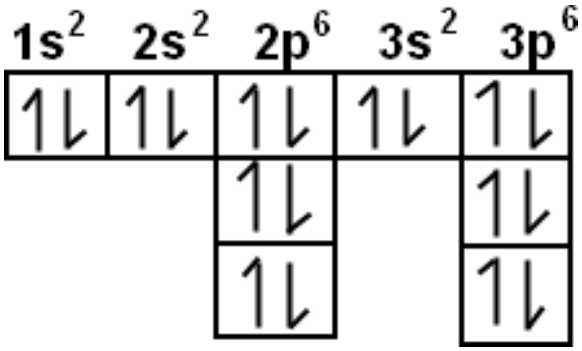
A. Gold

B. Copper

C. Magnesium

D. Iron

6 Below is a spdf electron configuration diagram. Which element is this?



A. Potassium

B. Sulfur

C. Iron

D. Argon

Section II

Data analysis and practicum skills (44 marks)

Answer questions in the space provided.

Show all relevant working in questions involving calculations.

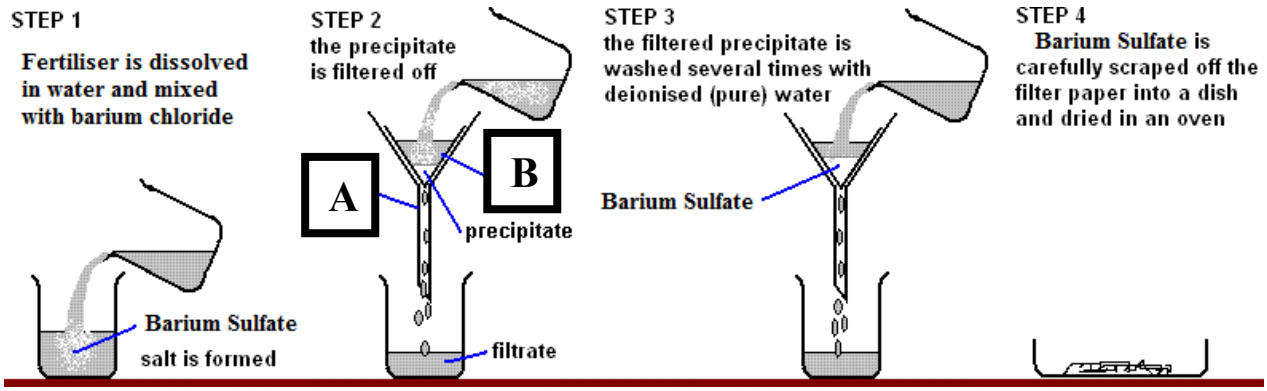
Question 7 **……./10 marks**

Four students analysed a sample of fertiliser to determine the amount of sulfate in it.

The formula for the sulfate ion is SO_4^{2-}.

The steps taken are shown in the diagram below.

By reacting a solution of fertiliser with a solution of barium chloride, a precipitate (solid) of barium sulfate will form.



a) Write the chemical molecular formula for barium sulfate. **(1)**

.....

b) Use the Periodic table to identify the Group and Period number for barium. **(1)**

.....

c) Identify the laboratory *equipment* labelled at A and B. **(1)**

.....

The results of the experiment are shown in the table below.

Student	*I* *Mass of fertiliser* *(g)*	*II* *Mass of barium sulfate precipitate* *(g)*	*III* *Mass of sulfate in precipitate* *(g)*	*IV* *Percentage of sulfate in fertiliser* *(%)*
A	11.6	19.5	8.0	
B	10.4	16.9	7.0	
C	10.3	22.6	9.3	
D	11.1	18.2	7.5	

d) An electronic balance was used twice in this experiment. What was it used for? **(2)**

e) If the mass of the barium sulfate precipitate (column *II*) was 100% and the mass of barium in the precipitate accounts for 58.8%, what is the percentage sulfate in the precipitate? **(1)**

f) The calculated mass of sulfate in the precipitate (column *III*) equals the mass of sulfate in the fertiliser.

Calculate the percentage sulfate in fertiliser and complete column *IV*.

Show your working for one of the student's results. **(2)**

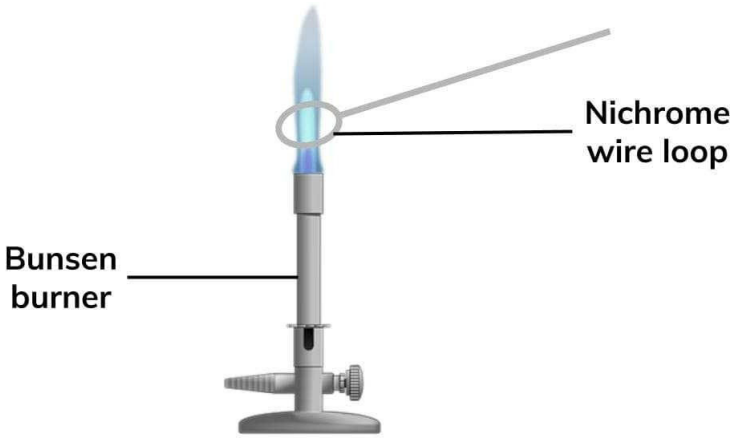
g) Student C found she had a relatively high amount of sulfate in her tested sample. All four students used the exact same brand of fertiliser. Account for the difference in results. **(2)**

Question 8 ……./**10 marks**

When ionic compounds are heated in a Bunsen burner flame, the colour of the flame may change depending on the metal in the compound.

Below is an extract from laboratory instructions on how to carry out a flame test.

> *Set up a Bunsen burner, light it and turn it to a blue (hot) flame.*
>
> *Clean the nichrome wire loop by dipping it into concentrated hydrochloric acid and then into the flame. Repeat this process until no colour is obtained. Allow the wire to cool before dipping into the acid (hot wire could cause the acid to spurt out).*
>
> *Place a small crystal of an unknown ionic compound onto a loop end of the wire. Place it into the flame. Note any changes in colour.*



The table below shows the colours displayed by some metals in a flame.

Metal	Lithium	Sodium	Potassium	Rubidium	Calcium	Barium	Strontium
Colour	Crimson	Yellow	Lilac	Ruby-red	Brick-red	Green	Scarlet

a) Are flame tests *quantitative* or *qualitative*? **(1)**

.....

b) Identify the colour you would expect from the following compounds when placed in a Bunsen burner flame: $SrCl_2$ and Rb_2SO_4. **(1)**

.....

.....

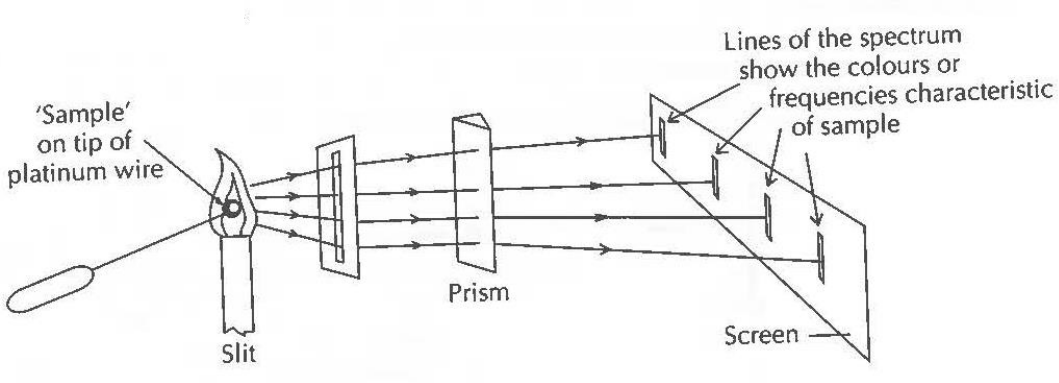
c) A student suggested that the results obtained for the compounds in question b) were not due to the metal present, but due to the non-metals in the compounds. How could you test this hypothesis? **(2)**

d) An alternative way of performing flame tests is by dissolving the compound in water and placing the solution in a small spray bottle.

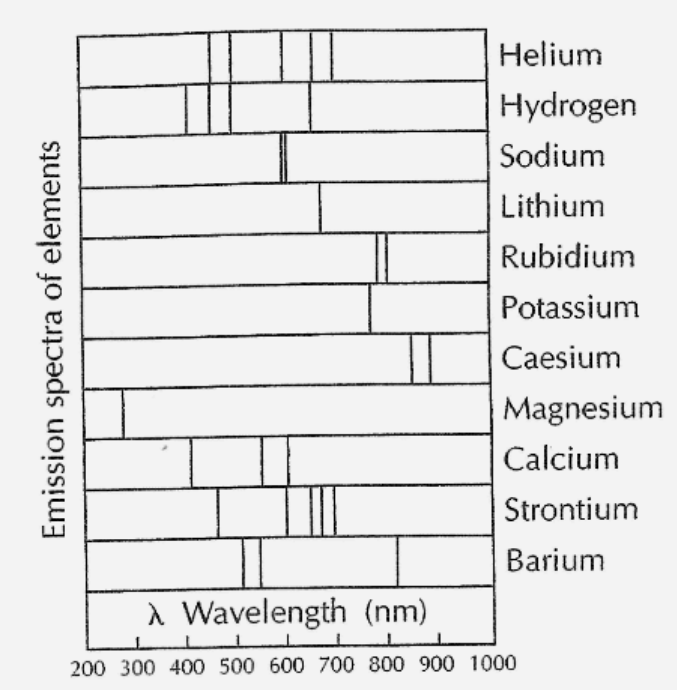
The spray bottle is aimed at the Bunsen burner flame and the solution sprayed into the flame as a fine mist.

Assess the risk(s) of the spray bottle method, and describe how the risk(s) could be minimized. **(2)**

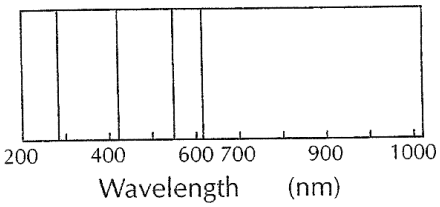
When the light emitted in a flame test is passed through a prism, the various specific wavelengths can be observed on an emission spectrum as shown in the diagram.



Each element has a unique emission spectrum and the emission spectra of a range of elements is shown below.



e) The emission spectrum of a mineral is shown below. Determine the elements present in the sample from the spectrum produced. **(2)**



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f) Spectroscopic analysis of star light revealed the presence of H and He. Which wavelengths would you expect to see on the emission spectrum? **(2)**

.....

.....

Question 9 ……./**8 marks**

Electrolysis of water is a chemical reaction in which water decomposes into oxygen and hydrogen gas, due to an electric current passed through the water.

In a Hoffman voltameter, these gases can be individually captured and the volumes measured.

Electrolysis of water was carried out in a laboratory and the volume of oxygen gas produced was recorded.

Time (min)	0	2	3	5	6	8
Volume of O_2 gas (mL)	0	5	9	14	18	23

a) Identify the independent variable. **(1)**

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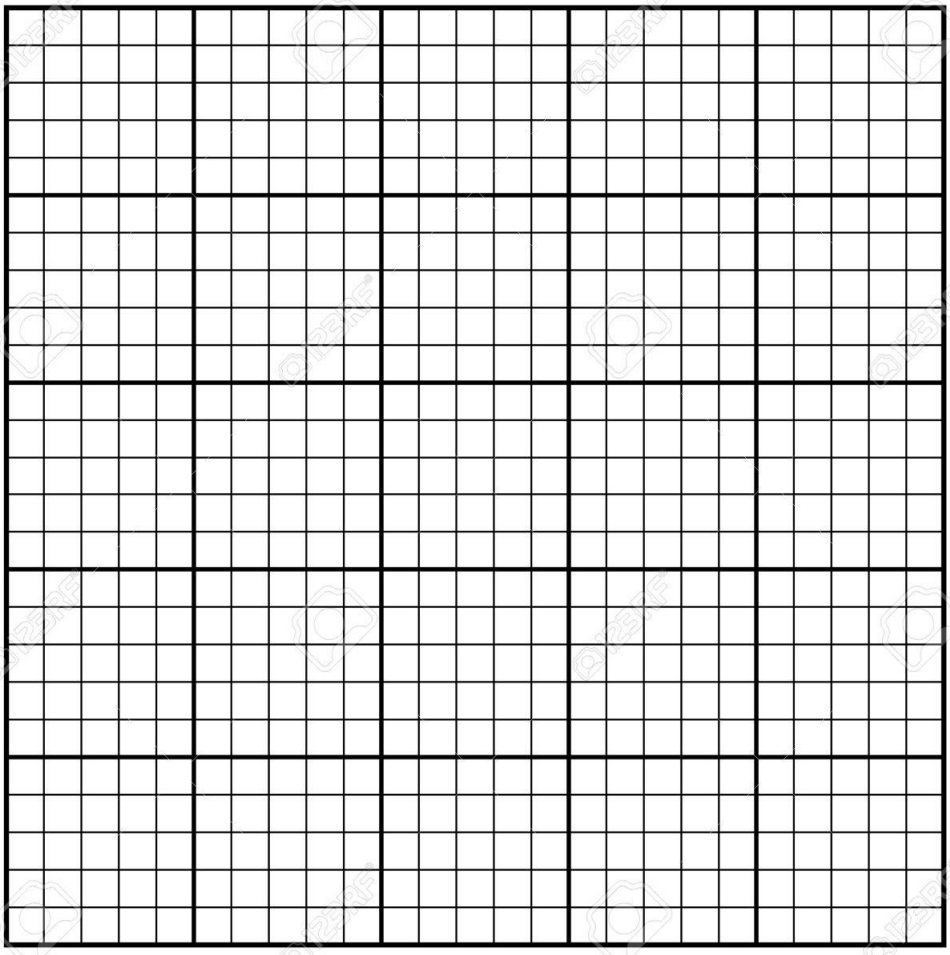
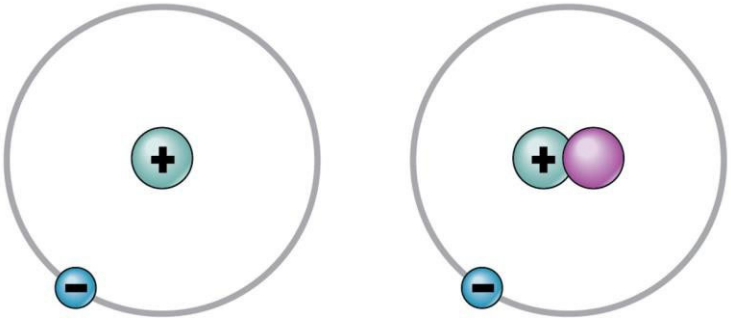
b) Plot the volume of oxygen gas over time. Draw a line of best fit. **(3)**



c) Assess the reliability of the experiment. **(2)**

d) Normal water contains two hydrogen atoms and one oxygen atom. Hydrogen (H-1) contains one proton and one electron.

Heavy water contains the hydrogen isotope deuterium. Deuterium (H-2) contains one proton, one neutron and one electron.



Hydrogen (H-1) **Deuterium (H-2)**

Assuming hydrogen and deuterium behave the same chemically, would electrolysis of heavy water produce less, equal or higher volumes of oxygen gas, compared to an equal volume of normal water? Explain your answer. **(2)**

Question 10 ……./**4 marks**

The physical and chemical properties of table salt (sodium chloride, NaCl) and glucose ($C_6H_{12}O_6$) were tested in a laboratory.

Test 1: Physical appearance.

- Salt is a white, crystalline solid and glucose is a white, powdery solid.

Test 2. Solubility in distilled water.

- Salt and glucose were both soluble in distilled water.

Test 3: Flame test.

- Salt gave a yellow flame colour, glucose did not change the flame colour

Test 4: Electrical conductivity.

- A solution of salt was electrically conductive. A solution of glucose was not electrically conductive.

Test 5: Precipitation test.

- When combined with a solution of silver nitrate, a precipitate (solid) formed with the salt solution, but not with the glucose solution.

a) Draw a table to list the observations. The table outline has been prepared. **(3)**

b) Using your table, identify which test(s) would ***not*** be helpful in differentiating between salt and sugar? **(1)**

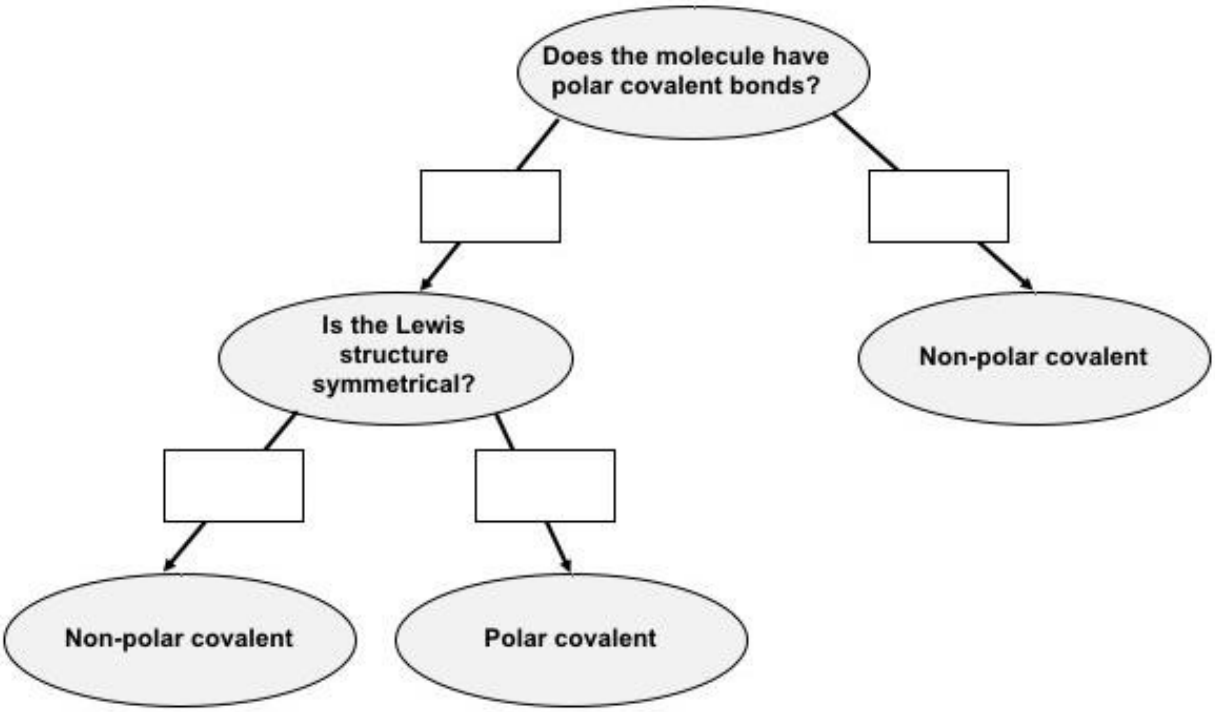
.....

.....

Question 11 ……./**2 marks**

Below is a flowchart which can be used to identify if a molecule is polar or non-polar.

Place the word "YES" or "NO" into the empty boxes.



Question 12 ……./**4 marks**

Nitrogen trifluoride is a colourless, odourless, non-flammable gas.

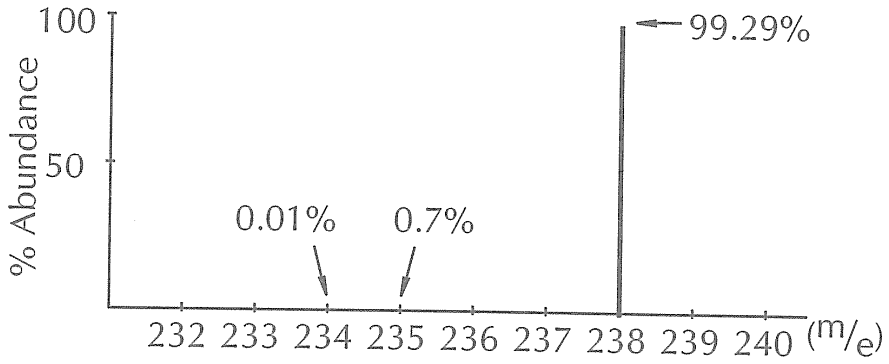
a) Draw a Lewis dot structure of this compound. **(2)**

b) Predict the intermolecular force in a pure sample of this compound. Explain your answer. **(2)**

Question 13 ……./**6 marks**

Uranium exists in three isotopic forms. The existence of these isotopes can be shown by placing a uranium sample in a mass spectrometer, in which atoms are vaporised, electrically charged and the ratio of the mass/charge for each is compared.

The mass spectrogram of uranium is shown below. The mass number is displayed on the x-axis and the % abundance on the y-axis.



a) What is the *Z* for uranium? **(1)**

b) Write the three isotopes of uranium. **(1)**

c) Using the mass spectrogram, calculate the relative atomic weight of natural uranium. Show your working. **(2)**

d) Uranium-235 decays to radium-227. Write the nuclear equation*s* to show the radioactive decay of uranium-235. **(2)**

Q1: B

Q2: D

Q3: C

Q4: D

Q5: A

Q6: D

2019 Answers

Section II

Data analysis and practicum skills (44 marks)

Answer questions in the space provided.

Show all relevant working in questions involving calculations.

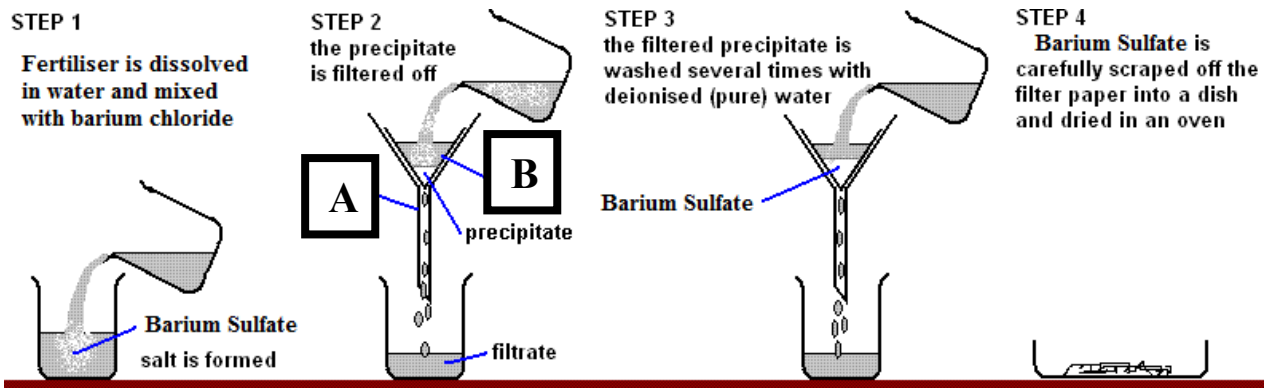
Question 7 **……./10 marks**

Four students analysed a sample of fertiliser to determine the amount of sulfate in it.

The formula for the sulfate ion is SO_4^{2-}.

The steps taken are shown in the diagram below.

By reacting a solution of fertiliser with a solution of barium chloride, a precipitate (solid) of barium sulfate will form.



a) Write the chemical molecular formula for barium sulfate. **(1)**

$BaSO_4$ (- ½ mark if charges were placed on top)

b) Use the Periodic table to identify the Group and Period number for barium. **(1)**

Group = 2 and period = 6 (will allow half marks, marker decides)

c) Identify the laboratory *equipment* labelled at A and B. **(1)**

A = funnel (if separating funnel was mention only ½ mark) , B = filter paper (will allow half marks, marker decides)

The results of the experiment are shown in the table below.

Student	*I* *Mass of fertiliser* *(g)*	*II* *Mass of barium sulfate precipitate* *(g)*	*III* *Mass of sulfate in precipitate* *(g)*	*IV* *Percentage of sulfate in fertiliser* *(%)*
A	11.6	19.5	8.0	69.0
B	10.4	16.9	7.0	67.3
C	10.3	22.6	9.3	90.3
D	11.1	18.2	7.5	67.6

d) An electronic balance was used twice in this experiment. What was it used for? **(2)**

1: weighing mass of fertiliser sample (1 mark)

2: weighing dried precipitate (1 mark)

e) If the mass of the barium sulfate precipitate (column *II*) was 100% and the mass of barium in the precipitate accounts for 58.8%, what is the percentage sulfate in the precipitate? **(1)**

100 – 58.8 = 41.2%

f) The calculated mass of sulfate in the precipitate (column *III*) equals the mass of sulfate in the fertiliser.

Calculate the percentage sulfate in fertiliser and complete column *IV*.

Show your working for one of the student's results. **(2)**

1 mark - shown a calculation for one of the students

1 mark – data in table has consistent sig figs/ rounded up correctly

(Mass sulfate in precipitate/mass of fertiliser) x 100% = % sulfate in fertiliser

(8.0/11.6) x 100% = 68.97 %

g) Student C found she had a relatively high amount of sulfate in her tested sample. All four students used the exact same brand of fertiliser. Account for the difference in results. **(2)**

1 mark – identifies the step where it went wrong (drying of precipitate)

1 mark – explains what went wrong (precipitate was not dried at all or not long enough)

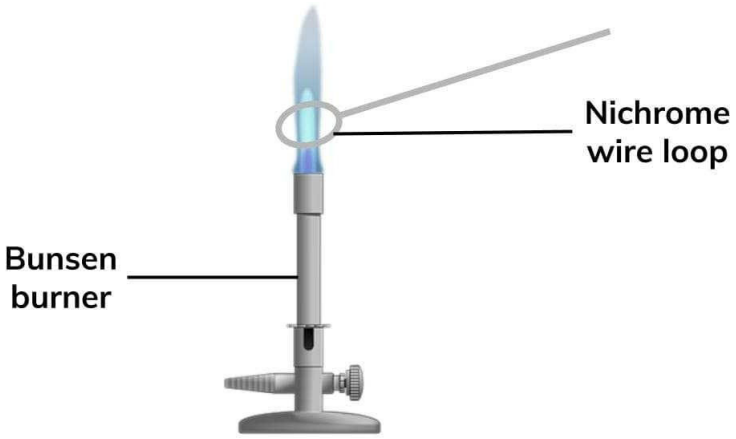
Or not of the fertiliser has dissolved

Question 8 ……./10 marks

When ionic compounds are heated in a Bunsen burner flame, the colour of the flame may change depending on the metal in the compound.

Below is an extract from laboratory instructions on how to carry out a flame test.

> *Set up a Bunsen burner, light it and turn it to a blue (hot) flame.*
>
> *Clean the nichrome wire loop by dipping it into concentrated hydrochloric acid and then into the flame. Repeat this process until no colour is obtained. Allow the wire to cool before dipping into the acid (hot wire could cause the acid to spurt out).*
>
> *Place a small crystal of an unknown ionic compound onto a loop end of the wire. Place it into the flame. Note any changes in colour.*



The table below shows the colours displayed by some metals in a flame.

Metal	Lithium	Sodium	Potassium	Rubidium	Calcium	Barium	Strontium
Colour	Crimson	Yellow	Lilac	Ruby-red	Brick-red	Green	Scarlet

a) Are flame tests *quantitative* or *qualitative*? **(1)**

Qualitative

b) Identify the colour you would expect from the following compounds when placed in a Bunsen burner flame: $SrCl_2$ and Rb_2SO_4. **(1)**

Scarlet and ruby red. No half marks, both correct for full mark.

Some mentioned brick-red (confused Cl with Ca)

Lost a mark if you said ruby-red for strontium and scarlet for rubidium (swapped)

c) A student suggested that the results obtained for the compounds in question b) were not due to the metal present, but due to the non-metals in the compounds. How could you test this hypothesis? **(2)**

1 mark –use of other compounds with same non-metal but different metal, or same metal but different non-metal

1 mark – what was the result you would expect to see if hypothesis correct or incorrect.

d) An alternative way of performing flame tests is by dissolving the compound in water and placing the solution in a small spray bottle.

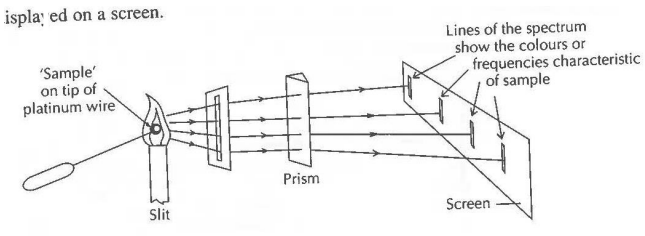
The spray bottle is aimed at the Bunsen burner flame and the solution sprayed into the flame as a fine mist.

Assess the risk(s) of the spray bottle method, and describe how the risk(s) could be minimized. **(2)**

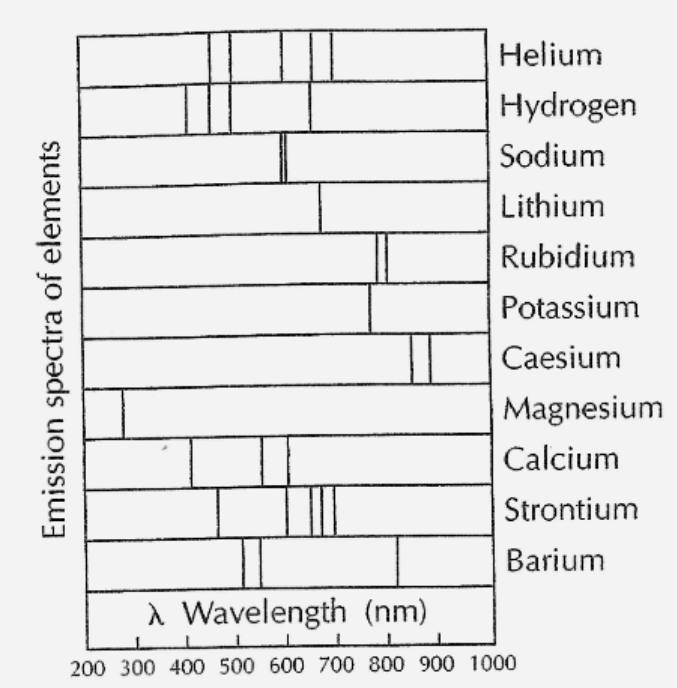
1 mark – identification of one or more risks, specifically related to use of spray bottle (only mentioning risk of Bunsen burner flame not sufficient)

1 mark – explained how to reduce risk(s)

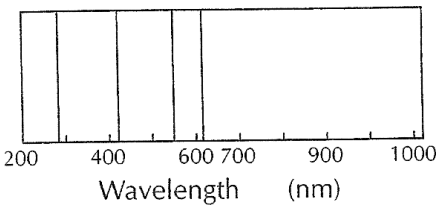
When the light emitted in a flame test is passed through a prism, the various specific wavelengths can be observed on an emission spectrum as shown in the diagram.



Each element has a unique emission spectrum and the emission spectra of a range of elements is shown below.



e) The emission spectrum of a mineral is shown below. Determine the elements present in the sample from the spectrum produced. **(2)**



1 mark – Magnesium, 1 mark – Calcium

-1 mark for each incorrect. Note: to identify an element, all lines need to be shown. Some found one line in the diagram matched an element and wrote that element down.

f) Spectroscopic analysis of star light revealed the presence of H and He. Which wavelengths would you expect to see on the emission spectrum? **(2)**

410 – 460 – 500 – 600 – 650 – 700 nm

-1 mark if one missed.

-1 mark if wavelength off by more than ~+/-20 nm

Note: some students gave the range, e.g. between 410-700 nm. The question specifically asks for which wavelengths you would expect to see.

Question 9 ……./**8 marks**

Electrolysis of water is a chemical reaction in which water decomposes into oxygen and hydrogen gas, due to an electric current passed through the water.

In a Hoffman voltameter, these gases can be individually captured and the volumes measured.

Electrolysis of water was carried out in a laboratory and the volume of oxygen gas produced was recorded.

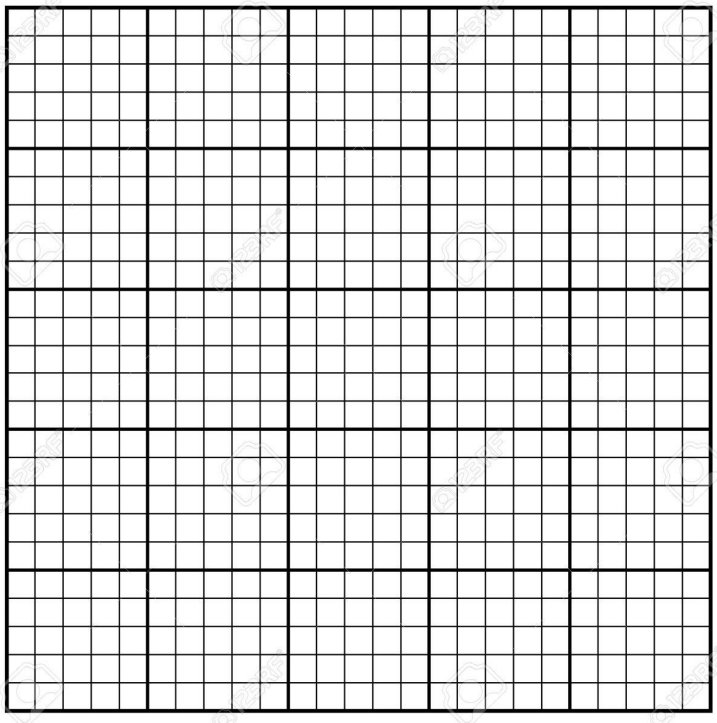
Time (min)	0	2	3	5	6	8
Volume of O_2 gas (mL)	0	5	9	14	18	23

a) Identify the independent variable. **(1)**

Time

b) Plot the volume of oxygen gas over time. Draw a line of best fit. **(3)**

1 mark – labelled x-axis time (min) and y-axis volume of oxygen gas (mL)
1 mark – correct plotting of x and y axis scale (x axis tricky)
1 mark – line of best fit
Note: some students chose very strange scale for x-axis. If you find it hard to come up with a scale, ask for more practice questions.



c) Assess the reliability of the experiment. **(2)**

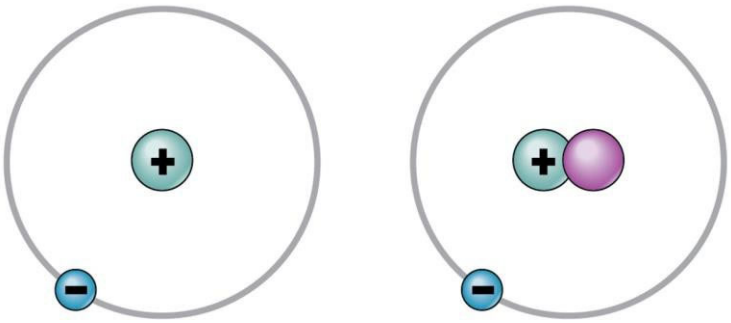
1 mark – it is NOT reliable

1 mark – because only one set of data was obtained.

Note: some students said it was reliable because the line of best fit was 'nice and straight'. Reliability = has the experiment been repeated three times and are the results similar?

d) Normal water contains two hydrogen atoms and one oxygen atom. Hydrogen (H-1) contains one proton and one electron.

Heavy water contains the hydrogen isotope deuterium. Deuterium (H-2) contains one proton, one neutron and one electron.



Hydrogen (H-1) **Deuterium (H-2)**

Assuming hydrogen and deuterium behave the same chemically, would electrolysis of heavy water produce less, equal or higher volumes of oxygen gas, compared to an equal volume of normal water? Explain your answer. **(2)**

1 mark – your answer

1 mark – answer explained

Note: most students said equal volumes as the oxygen atoms are not affected.

Some said less and had a good explanation.

If you lost a mark, please check comments. Some repeated the above text given as their answer, which was not sufficient for a mark.

Question 10 ……./**4 marks**

The physical and chemical properties of table salt (sodium chloride, NaCl) and glucose ($C_6H_{12}O_6$) were tested in a laboratory.

Test 1: Physical appearance.

- Salt is a white, crystalline solid and glucose is a white, powdery solid.

Test 2. Solubility in distilled water.

- Salt and glucose were both soluble in distilled water.

Test 3: Flame test.

- Salt gave a yellow flame colour, glucose did not change the flame colour

Test 4: Electrical conductivity.

- A solution of salt was electrically conductive. A solution of glucose was not electrically conductive.

Test 5: Precipitation test.

- When combined with a solution of silver nitrate, a precipitate (solid) formed with the salt solution, but not with the glucose solution.

a) Draw a table to list the observations. The table outline has been prepared. **(3)**

Test	Salt	Glucose
Physical appearance	White, crystalline solid	White powdery solid
Solubility in water	Soluble/Yes	Soluble/Yes
Flame test	Yellow	No change
Electrical conductivity	Conductive/Yes	Not conductive/No
Precipitation test	Yes/Precipitate formed	No/No precipitate formed

1 mark – correct column for tests
1 mark – correct column for salt and glucose
1 mark – correct completion of the results
Lost ½ mark if you didn't have Heading "test" or appropriate heading

b) Using your table, identify which test(s) would ***not*** be helpful in differentiating between salt and sugar? **(1)**

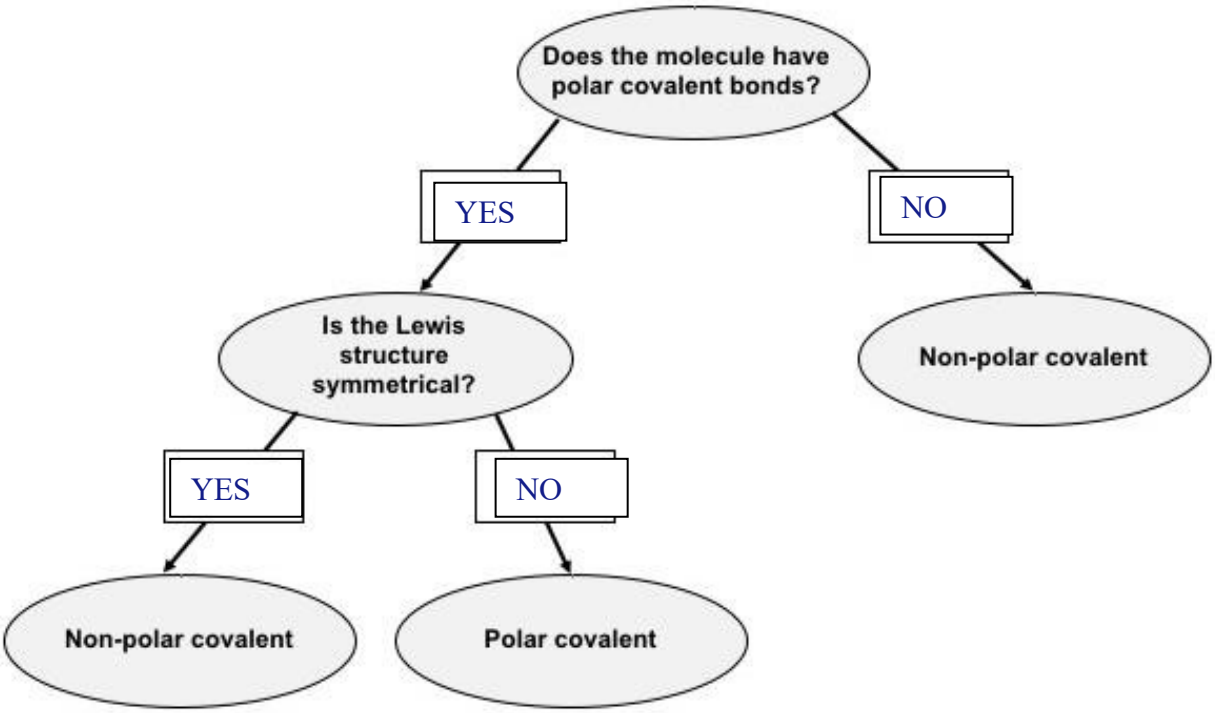
Physical appearance, solubility in water (if you just wrote solubility you got one mark as physical appearance not strictly a test)

Question 11 ……./**2 marks**

Below is a flowchart which can be used to identify if a molecule is polar or non-polar.

Place the word "YES" or "NO" into the empty boxes.

-1 mark for each error



Question 12 ……./**4 marks**

Nitrogen trifluoride is a colourless, odourless, non-flammable gas.

c) Draw a Lewis dot structure of this compound. **(2)**

1 mark – correctly identified type and number of atoms (NF_3)
1 mark – correctly drawn with only dots and F as trigonal pyramidal
-1/2 marks for minor errors

d) Predict the intermolecular force in a pure sample of this compound. Explain your answer. **(2)**

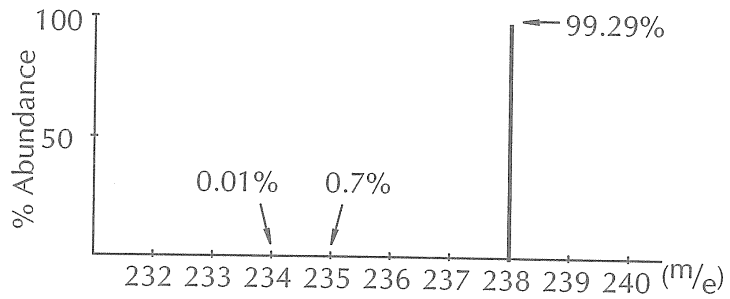
1 mark – dipole-dipole

1 mark – shape is trigonal pyramidal but bonds are N-F and not N-H so no hydrogen bond/ there is a net dipole as shape is not symmetrical

Question 13 ……./**6 marks**

Uranium exists in three isotopic forms. The existence of these isotopes can be shown by placing a uranium sample in a mass spectrometer, in which atoms are vaporised, electrically charged and the ratio of the mass/charge for each is compared.

The mass spectrogram of uranium is shown below. The mass number is displayed on the x-axis and the % abundance on the y-axis.



e) What is the *Z* for uranium? **(1)**

Atomic number is 92

f) Write the three isotopes of uranium. **(1)**

U-234, U-235, U-238 (no half marks) or written as $^{234}{}_{92}U$

g) Using the mass spectrogram, calculate the relative atomic weight of natural uranium. Show your working. **(2)**

1 mark – correct answer

1 mark – working shown

(0.01 x 234) + (0.7 x 235) + (99.29 x 238) /100 = 237.98 =238

h) Uranium-235 decays to radium-227. Write the nuclear equation*s* to show the radioactive decay of uranium-235. **(2)**

1 mark for each equation– correctly shown two equations

$_{92}{}^{235}U \rightarrow {}_{90}{}^{231}Th + {}_{2}{}^{4}He$ *then* $^{231}{}_{90}Th \rightarrow {}^{227}{}_{88}Ra + {}^{4}{}_{2}He$

If you used alpha symbol instead of He –still correct

IF you did it as one equation not showing Thorium -1 mark