Student Name: _____

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CHEMISTRY 2024

Unit 4
Key Topic Test 6 Experimental Design and Analysis

Recommended writing time*: 50 minutes
Total number of marks available: 50 marks

QUESTION BOOK

* The recommended writing time is a guide to the time students should take to complete this test. Teachers may wish to alter this time and can do so at their own discretion.

Conditions and restrictions

- Students are permitted to bring into the room for this test: pens, pencils, highlighters, erasers, sharpeners, rulers, a scientific calculator.
- Students are NOT permitted to bring into the room for this test: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 13 pages.
- 2024 VCE Chemistry Data Book

Instructions

- Print your name in the space provided on the top of the front page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the room for this test.

SECTION A – Multiple-choice questions

Instructions for Section A

Choose the most correct answer for each question. Each question is worth 1 mark.

Question 1

Which of the following pieces of data is qualitative?

A. Presence of bubbles

B. Temperature of solution

C. Concentration of solution

D. Volume of solution

Question 2

Which of the following statements best describes the term ‘accuracy’?

A. How close the results of an experiment are to each other, when repeated under the same conditions

B. How close the results of an experiment are to each other, when the same method is followed in a different laboratory.

C. How much the experiment measures what it aimed to measure.

D. How close a measured experiment results is to the true value of the quantity being measured.

Question 3

A student consistently reads a burette on an angle when completing a titration, and each reading is recorded as being 0.20 mL lower than the actual value. This type of error is best described as:

A. A random error

B. A systematic error

C. A mistake

D. A valid error

Question 4

The safety data sheet (SDS) for a chemical has the description ‘Harmful if swallowed or inhaled’. Which of the following is not likely be an additional precautionary measure listed?

A. Perform the experiment in a well-ventilated room.

B. Perform the experiment in a fume hood.

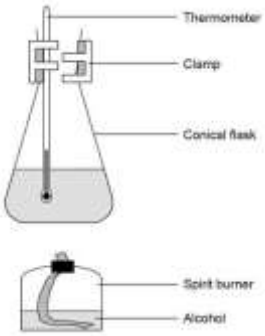
C. Perform the experiment away from open flames

D. Wear face protection.

Questions 5 and 6 relate to the following information

A student performed an experiment to determine and compare the molar heat of combustion of alcohols with differing carbon chain lengths.

They burned each of the alcohols in a spirit burner under a conical flask of water and recorded the temperature change of the water. They also recorded the mass of alcohol that underwent combustion. A set up of their experiment is shown below.



https://edu.rsc.org/experiments/comparing-heat-energy-from-burning-alcohols/1733.article

They used the results from the experiment to perform calculations to estimate the molar heat of combustion of each of the alcohols, as shown below.

Methanol	Ethanol	Propanol
$470\ kJ\ mol^{-1}$	$928\ kJ\ mol^{-1}*$	$1467\ kJ\ mol^{-1}*$

Question 5

Identify the independent variable of the experiment.

- **A.** The temperature change of the water
- **B.** The length of the carbon chain of the alcohol
- **C.** The mass of water in the beaker
- **D.** The volume of alcohol in the spirit burner.

Question 6

Which of the following statements most appropriately summarises the data collected?

- **A.** As the number of carbon atoms in the alcohol increases, the energy released upon combustion decreases.
- **B.** As the number of carbon atoms in the alcohol increases, the energy released upon combustion increases.
- **C.** As the number of carbon atoms in the alcohol increases, the mass of alcohol required for combustion increases.
- **D.** There is no relationship between the number of carbon atoms in the alcohol and the amount of energy released upon combustion.

Question 7

To determine the amount of ethanoic acid, in mole, the following calculation was performed:

$$n = cV$$

$$n = 0.10 \times 0.200$$

How many significant figures should the solution be recorded to?

A. 1
B. 2
C. 3
D. 0.02

Question 8

Which of the following pieces of information is not likely to be included in the introduction section of a scientific report?

A. Information from secondary sources related to the experiment
B. Diagrams or models relevant to chemical concepts related to the experiment
C. Analysis of the accuracy of the measurements from the experiment
D. Definitions of key terms related to the experiment

Question 9

If constructing a calibration curve from a series of standard solutions, the most appropriate way to present this data is:

A. Scatter graph
B. Column graph
C. Bar graph
D. Pie chart

Question 10

Which of the following is not an example of continuous data?

A. Temperature
B. Mass
C. pH
D. The number of carbon atoms in an alkane.

SECTION B- Short-answer Questions

Instructions for Section B

Answer all questions in the space provided. For questions involving calculations, provide your final answer to the appropriate number of significant figures, and with required units.

Question 1 (15 marks)

To investigate the energy content of savory biscuits in a laboratory, a student performed an experiment according to the method below.

Method:

1. Add 20.0 g of water to a test tube. Clamp to a retort stand on a slight lean. Clamp a thermometer above the test tube, so it is submerged in the water, but not touching the bottom. Record the initial temperature of the water.
2. Weigh a single biscuit and record its mass.
3. Take a wire needle and place it around the biscuit so it is held securely.
4. Light the biscuit on fire, and place under the test tube of water while it burns. If the flame goes out, relight the biscuit until it is completely burnt.
5. Once combustion is complete, record the final temperature of the water.
6. Weigh the remainder of the biscuit and record the mass.

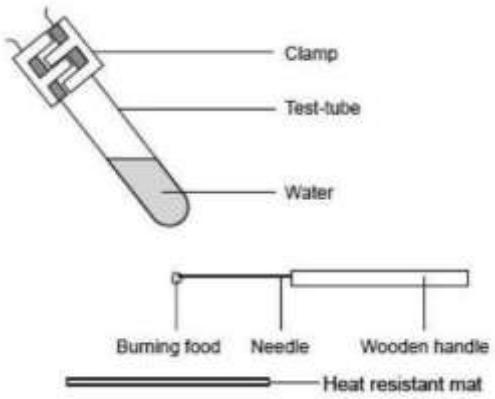


Image source:https://edu.rsc.org/experiments/energy-content-in-foods/397.article

The data collected in their logbook is shown below:

Mass of water in test tube	20.0 g
Initial temperature of water	23.5°C
Final temperature of water	62.0°C
Initial mass of biscuit	3.802 g
Final mass of biscuit	0.842 g

a. In addition to wearing personal protective equipment (PPE), identify a hazard present and a safety measure that should be in place when working with open flames.

_____

1 mark

b. Based on the data collected in the experiment, perform calculations to estimate the energy content of the biscuits in kJ g^{-1}.

_____

_____

_____

_____

_____

_____

3 marks

The student also recorded these additional observations in their logbook throughout performing the experiment.

Observations:

- Colour change of biscuit- black and charred following combustion.
- Black soot at bottom of test tube following combustion.

c. Classify the data collected as either 'qualitative' or 'quantitative'.

Information in logbook		Type of data
i.	Temperature of water	
ii.	Colour change of biscuit	
iii.	Black soot at bottom of tube	

3 marks

d. What inference can be drawn from the observation 'black soot at bottom of test tube'?

_____

_____

1 mark

Below shows the nutrition information from the packet for the biscuit under investigation, which the student wanted to compare their results to.

Macronutrient	Mass per 25.0 g serving
Carbohydrate	19.2 g
Protein	1.6 g
Fat	1.5 g

e. Based on the nutrition information on the packet, calculate the energy content of the biscuits in kJ g^{-1}.

_____

_____

2 marks

f. Compare the experiment results to the information provided on the packet. Identify an assumption made when performing calculations using experiment data.

_____

_____

_____

_____

2 marks

g. Identify a modification to the experiment method that could be made to improve the accuracy of data obtained.

_____

_____

1 mark

h. Define repeatability and explain how the student could evaluate the repeatability of the data collected.

_____

_____

_____

2 marks

1 + 3 + 3 + 1 + 2 + 2 +1 + 2 = 15 marks

Question 2 (15 marks)

The excerpt below is taken from a student logbook.

The Effect of Electrolyte Concentration on Rate of Electroplating

Aim: To investigate how electrolyte concentration affects the rate of electroplating.

Method:

1. Clean each metal electrode with steel wool, making sure there are no impurities visible on the surface.
2. Weigh the copper electrode and record the mass.
3. Add ~100 mL of 0.10 M zinc sulfate to the beaker. Ensure that the volume added is enough to be able to submerge the electrodes in solution.
4. Connect an alligator clip to the zinc electrode and attach the wire to the positive terminal of the DC power supply, including the ammeter in the circuit. Use a peg to hold the electrode in place at one side of the beaker.
5. Connect an alligator slip to the copper electrode and attach the wire to the negative terminal of the DC power supply. Use a peg to hold the electrode in place at the other side of the beaker. Ensure the two electrodes cannot touch in solution.
6. Set the power supply to 6.0 V and turn on. Start a timer for 20 minutes.
7. Record the current measured by the ammeter, and any other observations. After 20 minutes, turn the power supply off. Rinse the copper electrode with distilled water, and pat dry with paper towel. Weigh the electrode and record the final mass.
8. Repeat steps 1-7 using 0.50 M, and 1.00 M solutions of zinc sulfate.

Results:

Zinc sulfate concentration (M)	Mass of copper electrode before electroplating (g)	Mass of copper electrode after electroplating (g)	Current (amps)
0.10	3.262	3.344	0.30
~~0.50~~	~~3.248~~	~~3.318~~	~~0.25~~
0.50	3.543	3.766	0.60
1.00	3.346	3.732	1.10

Some information from the logbook is incomplete.

a. For the experiment, identify:

i. The independent variable.

_____

_____

ii. The dependent variable.

_____

_____

1 + 1 = 2 marks

b. Write a hypothesis for the investigation.

_____

_____

2 marks

c. Explain why a consistent duration of 20.0 minutes was included in the method for each different concentration of zinc sulfate used for electroplating.

_____

_____

_____

_____

2 marks

The student has crossed out a piece of data in their logbook after noticing the voltage of the power supply was set to 4.0 V instead of 6.0 V.

d. Classify this error and describe how the student appropriately addressed it.

_____

_____

_____

2 marks

e. Based on the experiment results, present the data to show relationship between electrolyte concentration and mass of zinc formed on the grid below.
Include:

i. A graph title. (1 mark)
ii. Axes labels. (2 marks)
iii. Axes scales. (2 marks)
iv. Data points using dots (•). (1 mark)
v. A line of best fit. (1 mark)

Title: _____

7 marks

2 + 2 + 2 + 2 + 7 = 15 marks

Question 3 (10 marks)

Ethanol is often an ingredient in mouthwash as it can prevent bacterial growth. A student was interested in performing an investigation to test for the presence of ethanol in different mouthwashes.

Test Tube 1	Test Tube 2	Test Tube 3	Test Tube 4	Test Tube 5
Deionised water	Alcohol-free mouthwash	Mouthwash brand 1	Mouthwash brand 2	Mouthwash brand 3

The student added acidified potassium dichromate to each of the test tubes, to test for the presence of ethanol.

a. Upon adding acidified potassium dichromate to each of the solutions, what colour change would indicate the presence of ethanol?

_____

1 mark

Important chemical equations and relevant key terms should always be included in scientific investigations.

b. Complete the information below that should be included in the introduction of the students report for this investigation.

i. Identify and describe the type of chemical reaction that occurs between ethanol and dichromate ions.

_____

_____

_____

_____

2 marks

Ethanol and dichromate ions react in acidic conditions to produce ethanoic acid and chromium (III) ions. Write balanced half-equations in acidic conditions for the two reactions that are occurring.

ii. Ethanol to produce ethanoic acid.

_____

_____

_____

1 mark

iii. Dichromate ions to produce chromium (III) ions.

_____

_____

_____

1 mark

A sample of deionised water and alcohol-free mouthwash were also tested in the experiment.

c. What is the purpose testing the deionised water and alcohol-free mouthwash?

_____

_____

1 mark

Assume Mouthwash brand 1, 2 and 3 all contained ethanol.

d. Describe a laboratory method that could be used to quantitatively compare the amount of ethanol present in each mouthwash.

_____

_____

_____

_____

2 marks

Another alcohol, 2-methylpropan-2-ol is often used in perfumes. A different student was interested in investigating the presence of this alcohol in different brands of perfume.

e. Explain why performing the above method to test for the presence of 2-methylpropan-2-ol in the different perfume samples would not be considered valid.

_____

_____

_____

_____

2 marks

1 + 2 + 1 + 1 + 1 + 2 + 2 = 10 marks

END OF KEY TOPIC TEST