Student Name: _____

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CHEMISTRY 2024

Unit 3
Key Topic Test 2 – Measuring Changes in Chemical Reactions

Recommended writing time*: 45 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,
- Permitted items include pens, pencils, erasers, sharpeners, rulers and VCAA Chemistry Data Book.
- Students are NOT permitted to bring into the room for this test: blank sheets of paper and/or white out liquid/tape.
- A scientific calculator is permitted in this test.

Materials supplied.

- Question and answer book of 12 pages.

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

Answer **all** questions.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.

Question 1

The complete combustion of 5.0 g of which of the following fuels produces the greatest mass of carbon dioxide.

A. Methane
B. Ethane
C. Ethanol
D. Hydrogen

Question 2

Equal volumes of methane, ethane, butane and ethyne are completely combusted at SLC. Which of these gases requires the greatest volume of oxygen for combustion?

A. Methane
B. Ethane
C. Butane
D. Ethyne

Question 3

The nutritional information for a particular biscuit state that the energy content is 2180 kJ/100g. A 1.5 g sample of the biscuit is combusted and used to heat 500.0 g of water. Assuming complete combustion of the biscuit and no loss of energy to the surroundings, the increase in temperature of the water would be closest to:

A. 10 ℃
B. 23 ℃
C. 2 ℃
D. 15 ℃

Question 4

100 g of water was heated in a calorimeter for 6.0 minutes. The voltage was recorded as 3.10 V and current as 2.0 A. The temperature of the water increased by 12.5 ℃. The calibration factor of the calorimeter is: J℃$^{-1}$

A. 3 J℃$^{-1}$
B. 215 J℃$^{-1}$
C. 300 J℃$^{-1}$
D. 180 J℃$^{-1}$

Question 5

3.0 L of H_2 and 5.0 L of N_2 react in a closed vessel. The volume of NH_3 produced (at SLC) is closest to:

A. 8.0 L
B. 4.0 L
C. 6.0 L
D. 2.0 L

Question 6

50.0 g of ethanol was reacted with 20.L of oxygen at SLC. What mass of water could be produced by the reaction?

A. 70.0 g
B. 76.0 g
C. 14.5 g
D. 19.5 g

Question 7

The amount of energy released by the complete combustion of 2.5 g of H_2 is closest to:

A. 700 kJ
B. 350 kJ
C. 25 kJ
D. 50 kJ

Question 8

0.75 g of methanol was combusted and used to heat 100 g of water. The temperature of the water increased by 29.0 ℃. The energy transformation efficiency of the heating of the water was closest to:

A. 50%
B. 60%
C. 70%
D. 80%

Question 9

50.0 g of a particular food was found to contain 25.0 g of carbohydrate, 15.5 g of fat and 7.0 g protein. The energy content of the food is closest to:

A. 1090 kJ/100g
B. 2200 kJ/100g
C. 1130 kJ/100g
D. 1590 kJ/100g

Question 10

Which of the following contains the most energy?

A. 6.0 g kerosene
B. 12.0 g diesel
C. 15.0 g octane
D. 3.0 mol butane

SECTION B

Instructions

Answer **all** questions in the spaces provided.
Where a numerical answer is required give your answer to the correct number of significant figures.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, any diagrams in this book are **not** drawn to scale.

Question 1 (23 marks)

A student carried out an experiment to investigate the heat of combustion of two alcohols, ethanol (1360 kJ/mol) and propanol (2021 kJ/mol). The temperature in the laboratory was 25.0℃ and the pressure 100 kPa.

Sections of their practical report are shown below.

Method:

- 100.0 mL of water was placed in a beaker which was clamped 10.0 cm above a spirit burner.
- The temperature of the water was recorded using a thermometer.
- The spirit burner was filled with the alcohol and weighed.
- The fuel was ignited and allowed to burn until the water increased in temperature by approximately 20.0^{o}C.
- The flame was extinguished, the spirit burner allowed to cool and then reweighed.
- The procedure was repeated with the second alcohol.

Results:

	Ethanol	**Propanol**
Mass of water (g)	100.0	100.0
Mass of burner and alcohol – initial (g)	130.52	148.50
Mass of burner and alcohol – final (g)	129.19	147.68
Temperature of water – initial (^{o}C)	17.5	18.0
Temperature of water – final (^{o}C)	37.9	38.7

(a) Complete the following table, showing the appropriate calculations.

	Ethanol	**Propanol**
Energy released by combustion of the alcohol (J).		
Energy absorbed by the water (J).		

4 marks

(b) Did the experimentally determined values for the heats of combustion agree with the values stated above? Account for any differences.

2 marks

(c) List two changes that could be made to the experimental design which would improve the accuracy of the results obtained.

2 marks

(d) Using the experimentally determined molar heats of combustion write balanced thermochemical equations for each of the reactions.

4 marks

(e) Using the experimentally determined results calculate the mass of carbon dioxide produced per kJ of energy for the ethanol.

4 marks

(f) Using the experimentally determined results for propanol calculate the volume of carbon dioxide produced per kJ of energy.

4 marks

(g) Calculate the energy efficiency of the apparatus used in the experiment for propanol.

3 marks

Question 2

13 marks

A solution calorimeter was calibrated electronically and used to determine the ΔH for the dissolution of solid calcium chloride hexahydrate ($CaCl_2.6H_2O$) in water to form Ca^{2+} and Cl^- ions. The table below shows experimental data for the calibration and the dissolution.

Calibration	
Volume of water (mL)	100
Voltage (V)	3.50
Current (A)	4.00
Time (s)	40.0
Temperature change (℃)	+ 0.800
Dissolution of $CaCl_2.6H_2O$ (s)	
Mass $CaCl_2.6H_2O$ (g)	7.00
Volume of water (mL)	100
Temperature change (℃)	-0.950

a. Calculate the calibration factor (C.F.) for the calorimeter (J ℃ $^{-1}$)

3 marks

b. Calculate the energy change for the dissolution of the calcium chloride hexahydrate (J).

2 marks

c. Determine the ΔH for the reaction (kJ mol^{-1}) and write the thermochemical equation.

4 marks

d. Predict the final temperature in the calorimeter if 3.00 g of calcium chloride hexahydrate were used and the initial temperature of the water was 19.0 ℃. Assume the same calorimeter and volume of water were used.

4 marks

Question 3

The production of biogas by anaerobic digestion of organic wastes has many stages. One of the reactions in this process is:

$$CH_3COOH\ (l) + H_2O\ (l) \rightarrow CH_4\ (g) + H_2O\ (g) + CO_2\ (g)$$

Determine the total volume (SLC) of greenhouse gases produced from the reaction of 300 g of CH_3COOH.

4 marks

Total 50 marks

END OF KEY TOPIC TEST