

Diagnostic Topic Test 2024

## VCE Chemistry Units 3&4

### Question and Answer Booklet

Test time: 45 minutes

Total marks: 35 marks

#### Test 1: What are the current and future options for supplying energy?

- Carbon-based fuels
- Measuring changes in chemical reactions

Student's Name: \_\_\_\_\_

Teacher's Name: \_\_\_\_\_

#### Instructions

Write your **name** and your **teacher's name** in the space provided above on this page.

A data booklet is provided.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Answer **all** questions in the spaces provided.

**SECTION A – MULTIPLE-CHOICE QUESTIONS****Instructions for Section A**

Circle the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

**Question 1**

A fuel is best defined as

- A. an energy resource that can be replaced in a relatively short time.
- B. the fossilised remains of organic matter formed over millions of years.
- C. any substance containing high-energy content that can be relatively easily released.
- D. any substance that can be reacted to release energy.

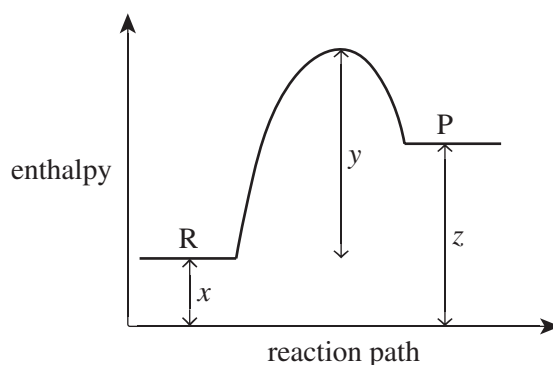
**Question 2**

What is the advantage of a biochemical fuel compared to the same compound derived from fossil fuels?

- A. No energy is used to extract and isolate a biochemical fuel from its source.
- B. The amount of energy per mole is greater for the biochemical fuel compound.
- C. Only the biochemical fuel is produced naturally in an endothermic reaction.
- D. The biochemical fuel can be replenished quickly using natural processes.

**Question 3**

Consider the following energy profile for a particular reaction.



Which of the following is an **incorrect** conclusion from the data presented?

- A. It takes more energy to break the bonds in the reactants than the energy released when the products form.
- B. The activation energy of the reverse reaction is  $x + y$ .
- C. The magnitude of the heat of reaction is equal to  $z - x$ .
- D. When the products form, after bonds in the reactants are broken, energy equivalent to  $x + y - z$  is released.

**Question 4**

Consider the complete combustion of the two fuels, methane and ethanol.

Which row in the following table correctly identifies the comparative features of the fuels?

	Fuel with the larger energy density ( $\text{kJ g}^{-1}$ )	Fuel producing the least energy for each mole of $\text{CO}_2$ produced
A.	methane	methane
B.	methane	ethanol
C.	ethanol	methane
D.	ethanol	ethanol

**Question 5**

The process of aerobic respiration that occurs in the cells of most living things is

- A. exothermic and involves the oxidation of carbon atoms.
- B. endothermic and involves the oxidation of carbon atoms.
- C. exothermic and involves the reduction of carbon atoms.
- D. endothermic and involves the reduction of carbon atoms.

**Question 6**

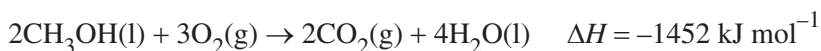
The energy content of a biscuit was to be determined using a calorimeter. The calorimeter was calibrated by passing a current of 1.16 A at a potential difference of 5.31 V through an electric heating coil for 3.00 minutes. The temperature rose by  $0.66^\circ\text{C}$ .

The calibration factor of the calorimeter, in  $\text{kJ } ^\circ\text{C}^{-1}$ , is

- A. 0.028
- B. 0.731
- C. 1.11
- D. 1.68

**Question 7**

Methanol burns according to the following equation.

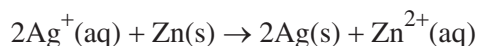


If 2.0 mol of gaseous methanol was completely reacted with oxygen gas, the energy released would be

- A. less than 1452 kJ.
- B. 1452 kJ.
- C. more than 1452 kJ.
- D. unable to be estimated from the information provided.

**Question 8**

During a solution calorimetry experiment, 0.546 g of zinc, Zn, was added to 50.0 mL of a 0.050 M silver nitrate solution,  $\text{AgNO}_3$ . Reaction occurred according to the following equation.



Which reagent will determine the maximum amount of energy that can be released in the exothermic reaction?

- A.  $\text{Ag}^+$ , because Zn is in excess by  $5.85 \times 10^{-3}$  mol
- B.  $\text{Ag}^+$ , because Zn is in excess by  $7.10 \times 10^{-3}$  mol
- C. Zn, because  $\text{Ag}^+$  is in excess by  $2.49 \times 10^{-3}$  mol
- D. Zn, because the solid reagent will always limit the amount of reaction that can occur

**Question 9**

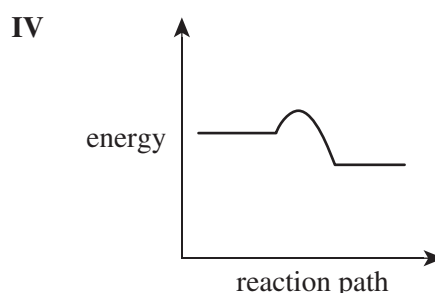
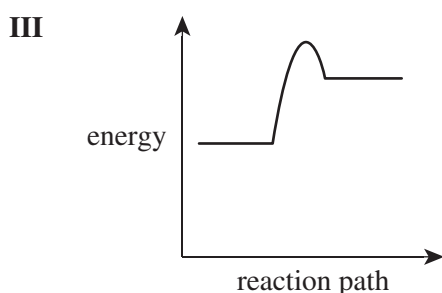
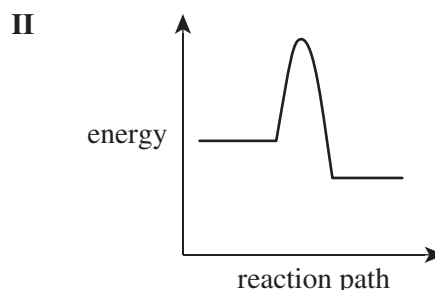
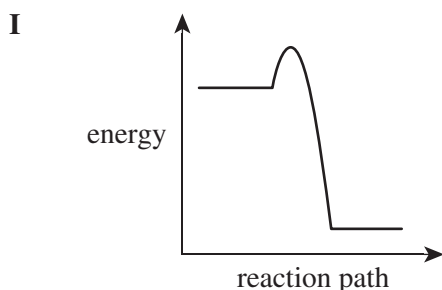
When 0.165 mol of a particular fuel is burnt completely, 225 kJ of energy is released.

The fuel is likely to be

- A. methane.
- B. propane.
- C. ethyne.
- D. ethanol.

**Question 10**

The energy profiles of four different reactions are shown below. Each profile is drawn to the same scale.



Which profile is likely to be that of a fuel?

- A. I
- B. II
- C. III
- D. IV

**END OF SECTION A**

**SECTION B****Instructions for Section B**

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example,  $\text{H}_2(\text{g})$ ,  $\text{NaCl}(\text{s})$ .

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

**Question 1** (9 marks)

- a.** Solar energy is a promising renewable energy source. One method of capturing solar energy is through its use in producing biomass and subsequent production of biofuels. Biomass refers to organic matter derived from living or recently living organisms.

- i.** Write a balanced equation to represent the process by which green plants convert solar energy into the chemical energy in biomass, using carbon dioxide and water as reactants to produce glucose and oxygen.

2 marks

- ii.** The energy stored in biomass can be released by direct combustion, in the burning of wood for example.

What is a disadvantage of this direct combustion of biomass as an energy source?

1 mark

- iii.** Alternatively, the energy stored in biomass can be released through conversion of biomass to bioethanol. Bioethanol may be produced by the fermentation of a glucose solution using yeast enzymes.



What volume of gas, measured at standard laboratory conditions (SLC), would be evolved if 9.0 g of glucose undergoes fermentation?

3 marks

- b.** Biochemical fuels, such as bioethanol, may be classified as 'carbon neutral', which means that they do not increase the amount of carbon dioxide in the atmosphere over time.
- i.** Explain why biochemical fuels may be classified as 'carbon neutral'. 2 marks
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- ii.** Describe **one** possible disadvantage of using biochemical fuels such as bioethanol. 1 mark
- \_\_\_\_\_
- \_\_\_\_\_

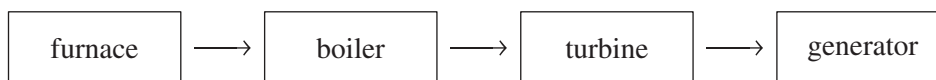
**Question 2** (10 marks)

Natural gas is a very important and widely used energy source in society. It consists primarily of methane.

- a.** The gas is piped to homes to be burnt for heating and cooking purposes.
- i.** Give a balanced thermochemical equation for the complete combustion of methane. 2 marks
- \_\_\_\_\_
- ii.** Calculate the mass of methane (in grams) required to bring to the boil 750 mL of water at an initial temperature of 15°C. Assume that 65% of the energy produced by the burning methane is used to heat the water. 3 marks
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

- b. Natural gas is also used for electricity generation in **gas-fired** power stations. In these stations, hot gases produced in a combustion reaction expand air in a combustion turbine, spinning the turbine blades and the attached electricity generator.

The flowchart below shows the major components of a **coal-fired** power station.



- i. The coal-fired power station has an energy efficiency of 30%.

Explain what is meant by this energy efficiency value.

1 mark

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- ii. Give **one** reason why gas-fired power stations achieve a higher energy efficiency in electricity output than coal-fired power stations.

1 mark

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- iii. State a way in which waste material from electricity production in gas and coal-fired power stations may adversely affect the environment.

1 mark

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- c. Methane can be considered as both a renewable and non-renewable energy source.

Explain this statement.

2 marks

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**Question 3** (6 marks)

- a.** The energy content of cashew nuts was determined by experiment. 0.286 g of crushed cashew nut was burnt in a calorimeter and produced a temperature increase of 7.65°C. The energy of the nut based on this experiment was found to be 23.6 kJ g<sup>-1</sup>.

What was the calibration factor of the calorimeter used?

2 marks

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- b.** A label on the cashew nut package gave the following composition by mass.

	Carbohydrate	Protein	Fats and oils
Composition (%)	28	18	47

Based on these composition figures, calculate the energy that would be released on the complete combustion of 1.0 g of cashew nut.

2 marks

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- c.** The value determined in **part b.** for the energy content of cashew nuts is greater than the experimental value given in **part a.**  
A student wrote the following possible explanations for the difference in the two values.

- I The cashew nut was not crushed sufficiently in the calorimeter experiment.
- II The calorimeter was calibrated containing 900 mL of water, but the experiment was conducted using 850 mL of water in the calorimeter.
- III The label on the package includes the mass of cellulose in the carbohydrate value. This cellulose would not provide energy when combusted in the calorimeter.

Select **one** explanation from the list above and comment on whether the explanation could account for the difference in the energy content value given in **part a.** and the value determined in **part b.**

2 marks

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**END OF TEST**