Neap:

CHEMISTRY VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2008

TEST 7: ENERGY SOURCES AND THE ENERGY OF CHEMICAL REACTIONS

TOTAL 35 MARKS (45 MINUTES)

Student's Name: ______________________ Teacher's Name: ______________________

Directions to students

Write your name and your teacher's name in the spaces provided above.
Answer all questions in the spaces provided.

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

For each question in Section A, choose the response that is correct and circle your choice.
Choose the response that is **correct** or **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.

Question 1

The combustion of coal is the major energy source in the generation of electricity in Australia.

Which of the following is **not** used to generate electricity in Australia?

A. natural gas
B. solar energy
C. hydroelectricity
D. nuclear fission

Question 2

Ethanol is a biochemical fuel that is gaining importance as an alternative or additive to petroleum-based fuels in cars and trucks.

Which of the following processes is used to produce commercial quantities of ethanol for this purpose?

A. fermentation of glucose from crops such as corn and sugar cane
B. fractional distillation of crude oil
C. reaction of vegetable oils and animal fats with methanol
D. decomposition of organic wastes by bacteria under anaerobic conditions

Question 3

Brown coal has an energy content of approximately 12 kJ g^{-1}, and the efficiency of power generation is 35%. On very hot days in Victoria, the peak demand for electricity can reach 9000 MW, or 9.0×10^6 kJ of energy per second.

The mass of coal that would need to be burnt every second to generate this amount of power is

A. 260 kg

B. 750 kg

C. 2100 kg

D. 3.8×10^4 kg

Question 4

Consider the following thermochemical equations.

$$2CH_3OH(aq) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l) \quad \Delta H = -1453 \text{ kJ mol}^{-1}$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -393.5 \text{ kJ mol}^{-1}$$

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \quad \Delta H = -571.6 \text{ kJ mol}^{-1}$$

The enthalpy of reaction for $C(s) + 4H_2(g) + CO_2(g) \rightarrow 2CH_3OH(aq)$ is

A. –2418 kJ mol^{-1}

B. –83.7 kJ mol^{-1}

C. +487.9 kJ mol^{-1}

D. +1809 kJ mol^{-1}

Question 5

A bushwalker needs to boil some water to make her dinner. She is carrying a small canister of butane gas under pressure, which burns in air according to the following thermochemical equation.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l) \quad \Delta H = -5750 \text{ kJ mol}^{-1}$$

Given that 74.9 kJ of energy is required to heat the saucepan and boil the water, the mass of butane required is

A. 0.0261 g

B. 0.756 g

C. 1.51 g

D. 3.02 g

Question 6

Zinc sulfide ores such as sphalerite (ZnS) are 'roasted' in air during the first step in producing zinc metal. The equation for this reaction is

$$ZnS(s) + 3O_2(g) \xrightarrow{\Delta} 2ZnO(s) + 2SO_2(g) \quad \Delta H = -8791 \text{ kJ mol}^{-1}$$

How much energy would be needed to generate 1.00 tonne of zinc oxide from a sufficient quantity of sphalerite?

A. 45.1 MJ

B. 54.0 MJ

C. 90.2 MJ

D. 108 MJ

Question 7

250.0 g of ethanol is placed into an aluminium container of mass 180.0 g. The temperature of both the ethanol and container increases from 15.6°C to 33.9°C with the addition of 14.2 kJ of energy.

Given that the specific heat capacity of ethanol is 2.46 J °C^{-1} g^{-1}, the specific heat capacity of aluminium is

A. 0.894 J °C^{-1} g^{-1}

B. 1.03 J °C^{-1} g^{-1}

C. 1.09 J °C^{-1} g^{-1}

D. 4.18 J °C^{-1} g^{-1}

Question 8

Cyanogen (C_2N_2) is a colourless, poisonous gas that has been discovered in trace amounts in the atmosphere of Titan, the largest of Saturn's moons. Cyanogen undergoes combustion in a highly exothermic process according to the following equation.

$$C_2N_2(g) + 2O_2(g) \rightarrow N_2(g) + 2CO_2(g)$$

Given that 15.0 g of cyanogen produces 312 kJ of energy when reacted with oxygen, the enthalpy of combustion (ΔH) is

A. –20.8 kJ mol^{-1}

B. –90.0 kJ mol^{-1}

C. –1080 kJ mol^{-1}

D. –4680 kJ mol^{-1}

Question 9

A solution calorimeter is calibrated by passing a current of 3.18 A at a potential difference of 4.72 V for a period of 2 minutes and 30 seconds. Over this time, the temperature of the solution within the calorimeter increases from 17.0°C to 26.9°C.

The calibration factor for the calorimeter is

A. 0.989 J °C^{-1}

B. 3.79 J °C^{-1}

C. 83.7 J °C^{-1}

D. 227 J °C^{-1}

Question 10

Calibration of a particular bomb calorimeter determines that its calibration factor is 1.07 kJ °C^{-1}. A 0.841 g sample of quinone ($C_6H_4O_2$) is burned in the calorimeter, and the temperature rises from 24.4°C to 44.5°C.

The heat of combustion of quinone is

A. –6.90 kJ mol^{-1}

B. –21.7 kJ mol^{-1}

C. –25.8 kJ mol^{-1}

D. –2790 kJ mol^{-1}

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

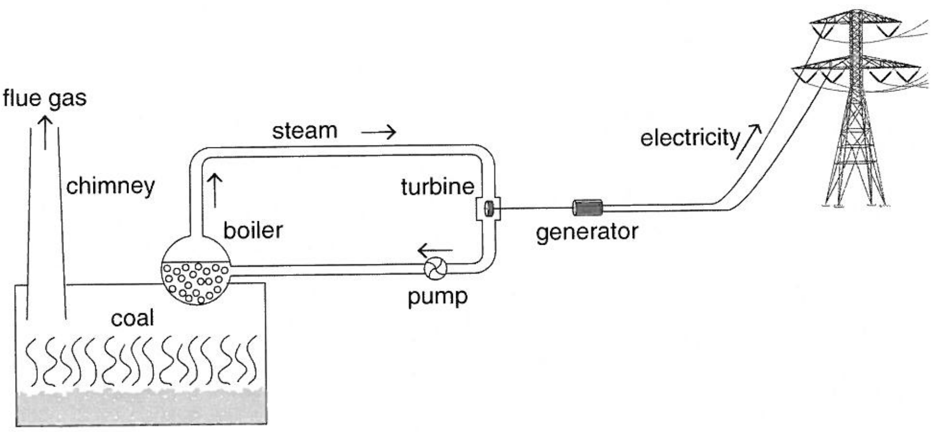
Answer **all** questions in the spaces provided.
To obtain full marks you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example $H_2(g)$; NaCl(s).

Question 1

Coal is the major fuel used in the production of electricity in this country. Coal contains a large proportion of carbon which undergoes combustion in power stations according to the equation

$$C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -394 \text{ kJ mol}^{-1}$$



a. The energy generated in power stations is present in several different forms as it passes through the generation process.

What form of energy is present in the

i. coal?

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ii. steam?

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iii. spinning turbine?

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iv. generator?

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$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = 2$ marks

b. The overall energy efficiency of a particular coal-fired power station in Victoria is 30%. Unlike New South Wales and Queensland, Victoria uses brown coal rather than black as its principal fuel source.

i. State one significant reason why brown coal (lignite) is classed as an inferior fuel compared to black coal.

ii. State **one** of the major causes of inefficiency in coal-fired power stations.

1 + 1 = 2 marks

c. Australia has vast reserves of uranium ores and yet has no nuclear-powered electricity generating plants at all. It has been estimated that the fission of 1 kg of uranium would yield as much energy as 2500 tonnes of coal with negligible greenhouse gas emissions.

i. Briefly explain how the energy stored in the nucleus of uranium atoms is used to generate electricity in a nuclear power station

ii. Despite the promise of abundant energy from nuclear reactions, only 17% of the world's electrical energy is derived from nuclear power compared to 65% from fossil fuels.

State two possible reasons why nuclear power is not more widely used across the globe.

2 + 2 = 4 marks
Total 8 marks

Question 2

a. The latent heat of vapourisation of a substance is defined as the amount of energy required to change a given mass of that substance from the liquid to the gaseous state.

Given that 548 kJ of energy is required to convert 500 mL of liquid ammonia at –33°C to its gaseous state at the same temperature, calculate the latent heat of vapourisation of ammonia in J g^{-1}. The density of liquid ammonia is 0.80 g mL^{-1}.

2 marks

b. Methane undergoes combustion readily to produce carbon dioxide and water according to the thermochemical equation

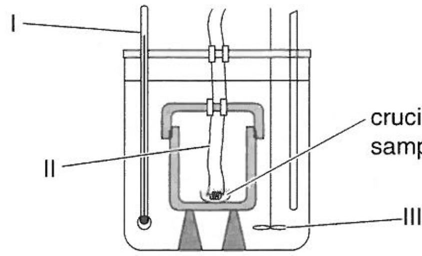
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \quad \Delta H = -890 \text{ kJ mol}^{-1}$$

Calculate the volume of methane gas at SLC that would be required to produce 548 kJ of energy and so vapourise the sample of ammonia.

2 marks
Total 4 marks

Question 3

a. The enthalpy of combustion of fuels can be determined using a bomb calorimeter. A simplified diagram of such a calorimeter is shown below.



Explain the role of

i. component I.

ii. component II.

iii. component III.

1 + 1 + 1 = 3 marks

b. The most common way of calibrating a calorimeter is to determine the temperature increase caused by the input of a measured amount of electrical energy. An alternative technique is to measure the temperature change caused by the combustion of a given mass of a reactant for which the enthalpy of reaction is known. Benzoic acid is commonly used for this purpose.

$$2C_6H_5COOH(s) + 15O_2(g) \rightarrow 14CO_2(g) + 6H_2O(l) \quad \Delta H = -6454 \text{ kJ mol}^{-1}$$

i. Determine the calibration factor for a particular bomb calorimeter given that the combustion of 1.731 g of benzoic acid caused the temperature of the calorimeter and its contents to increase by 24.8°C.

ii. What would be the effect on the calibration factor of the calorimeter if the chamber surrounding the crucible had been filled with ammonia rather than water? The specific heat capacity of water is 4.18 J °C g^{-1} and of ammonia is 2.06 J °C g^{-1}.

2 + 1 = 3 marks

c. **i.** The same calorimeter was then used to determine the enthalpy of combustion of a sample of biofuel derived from the fermentation of agricultural wastes. 3.00 mL of the biofuel was introduced into the combustion chamber of the calorimeter along with excess oxygen gas at a pressure of 2 MPa. The mixture was then ignited with an electrical discharge. The temperature of the calorimeter and its contents increased from 35.3°C to 65.6°C.

Calculate the heat of combustion of the biofuel in MJ L^{-1}.

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ii. The biofuel tested consists primarily of ethanol with small amounts of methanol, propanol and other organic molecules. In a separate experiment, 2.50 g of pure ethanol undergoes combustion in the same calorimeter according to the equation

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -1360 \text{ kJ mol}^{-1}$$

Determine the increase in temperature that would occur in the calorimeter as a result of this reaction.

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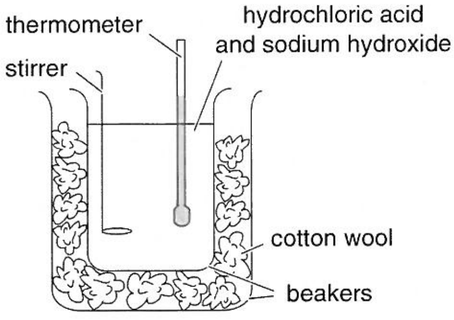
2 + 2 = 4 marks
Total 10 marks

Question 4

The reaction between an acid and an alkali is called neutralisation and can be represented by the ionic equation below.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l) \quad \Delta H < 0$$

A simplified version of a solution calorimeter was set up by a student to determine the heat of neutralisation of the reaction between hydrochloric acid and sodium hydroxide.



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

volume of 0.50 M HCl	100.0 mL
volume of 0.50 M NaOH	100.0 mL
initial temperature of HCl solution	18.6°C
initial temperature of NaOH solution	18.6°C
final temperature of solution after reaction	21.7°C

You may assume that the specific heat capacity of all solutions is the same as that of water: 4.18 J °C g^{-1}.

a. **i.** Calculate the amount of energy produced by the neutralization reaction.

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ii. The equation that represents this reaction is $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$.

Determine the heat of neutralisation.

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1 + 1 = 2 marks

b. The experimentally determined value for the heat of neutralisation was significantly lower than the expected theoretical value.

State two modifications that the student could make to the experimental apparatus to improve the accuracy of the results of any subsequent experiments.

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1 mark

Total 3 marks