Energetics Practice Test Mr Cole Chemistry

Name ..... Class: .....

Start Time ..... End Time ..... Time Taken .....

Time allowed: 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name in the space above.
Fill in the time you start and the time you finish the test.
Answer all the questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part of a question.
The marks allocated and the spaces provided for your answers are a good indication of the length of answers required.

Success Criteria	Questions in Paper	Mark	Out of	%	Rank Order
Definitions	3a, 3b, 5ai		5		
Formation Data Hess Diagrams	2b, 9		4		
Bond enthalpy Hess Diagrams	2c, 7		4		
Differences	2d, 6c		4		
Unusual Hess Diagrams	3c,		3		
Calorimetry	4, 5aii, 6b		16		
Enthalpy of Combustion Hess Diagrams	5b, 6d		6		
Equations	1, 2a, 6a		3		
Experimental techniques	8		2		
Total			47		

Q1.

Which equation represents the reaction that has a standard enthalpy change equal to the standard enthalpy of formation for barium chloride?

A $Ba(g) + Cl_2(g) \rightarrow BaCl_2(s)$ ⬭

B $Ba^{2+}(g) + 2\ Cl^-(g) \rightarrow BaCl_2(s)$ ⬭

C $Ba(s) + Cl_2(g) \rightarrow BaCl_2(s)$ ⬭

D $Ba^{2+}(s) + 2\ Cl^-(g) \rightarrow BaCl_2(s)$ ⬭

(Total 1 mark)

Q2.

This question is about energetics.

(a) Write an equation, including state symbols, for the reaction with an enthalpy change equal to the enthalpy of formation for iron (III) oxide.

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(1)

(b) **Table 1** contains some standard enthalpy of formation data.

Table 1

	$CO(g)$	$Fe_2O_3(s)$
$\Delta_f H^\ominus$ / kJ mol^{-1}	−111	−822

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$ $\Delta H = -19$ kJ mol^{-1}

Use these data and the equation for the reaction of iron(III) oxide with carbon monoxide to calculate a value for the standard enthalpy of formation for carbon dioxide.

Show your working.

(3)

(c) Some enthalpy data are given in **Table 2**.

Table 2

Process	**ΔH / kJ mol^{-1}**
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	−92
$N_2(g) \longrightarrow 2N(g)$	+944
$H_2(g) \longrightarrow 2H(g)$	+436

Use the data from **Table 2** to calculate the bond enthalpy for N−H in ammonia.

(3)

(d) Give one reason why the bond enthalpy that you calculated in part (c) is different from the mean bond enthalpy quoted in a data book (388 kJ mol^{-1}).

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(1)
(Total 8 marks)

Q3.

Hess's Law is used to calculate the enthalpy change in reactions for which it is difficult to determine a value experimentally.

(a) State the meaning of the term *enthalpy change*.

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(1)

(b) State Hess's Law.

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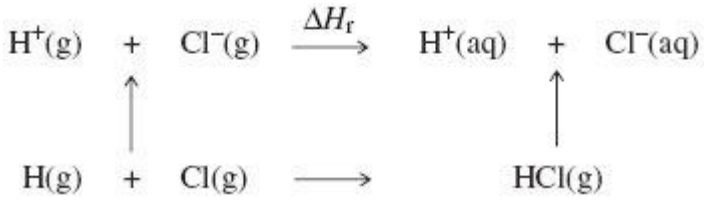
(1)

(c) Consider the following table of data and the scheme of reactions.

Reaction	Enthalpy change / kJ mol^{-1}
$HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$	–75
$H(g) + Cl(g) \rightarrow HCl(g)$	–432
$H(g) + Cl(g) \rightarrow H^+(g) + Cl^-(g)$	+963



Use the data in the table, the scheme of reactions and Hess's Law to calculate a value for ΔH_r

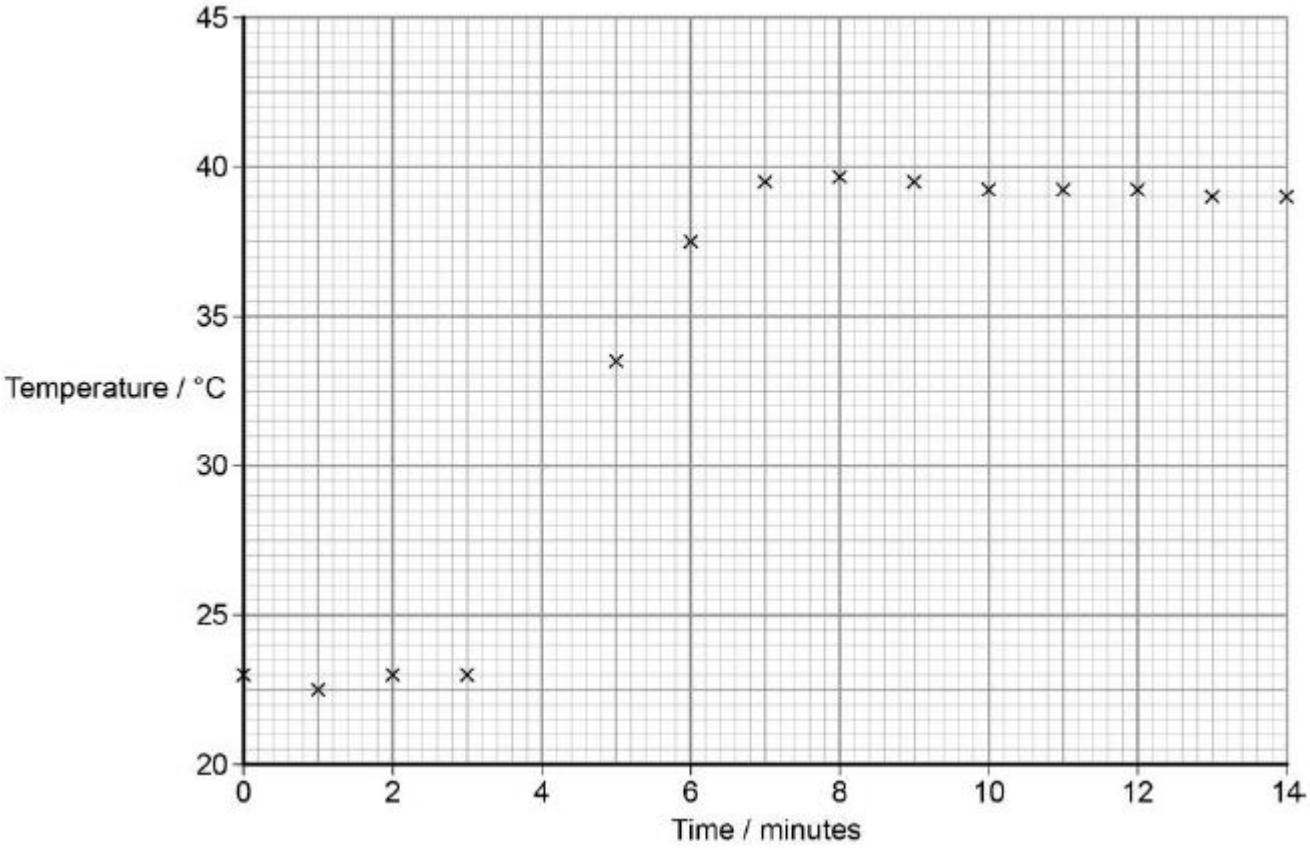
(3)
(Total 5 marks)

Q4.

A student carried out a reaction between magnesium ribbon and aqueous trichloroethanoic acid in order to determine the enthalpy change. The equation for the reaction is shown:

$$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$$

The student measured the initial temperature of the trichloroethanoic acid and again every minute for 3 minutes before adding the magnesium ribbon at the fourth minute.
The student continued to measure the temperature every minute for a further 10 minutes.
The graph for these measurements is shown on the next page.



The student used 240 mg of magnesium and 10.0 cm^3 of aqueous trichloroethanoic acid (an excess).

Use these data and information determined from the graph above to calculate the enthalpy change, in kJ mol^{-1}, for this reaction.
Show your working.
Give your answer to an appropriate precision.
(The specific heat capacity of water = 4.18 J K^{-1} g^{-1})

(Total 7 marks)

Q5.

Methanol, CH_3OH, is a convenient liquid fuel.

(a) An experiment was conducted to determine the enthalpy of combustion of liquid methanol. The energy obtained from burning 2.12 g of methanol was used to heat 150 g of water. The temperature of the water rose from 298 K to 362 K. (The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

(i) Define the term *standard enthalpy of combustion*.

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(3)

(ii) Use the data above to calculate a value for the enthalpy of combustion of one mole of liquid methanol.

(4)

(b) The standard enthalpies of combustion of carbon monoxide and of hydrogen are –283 kJ mol^{-1} and –286 kJ mol^{-1}, respectively. Use these data and the enthalpy change for *Stage 2* to calculate a value for the standard enthalpy of combustion of gaseous methanol.

Stage 1 $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H^{\ominus} = +206$ kJ mol^{-1}

Stage 2 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H^{\ominus} = -91$ kJ mol^{-1}

(3)

(Total 15 marks)

Q6.

(a) Write an equation for the complete combustion of propanone, C_3H_6O, to form carbon dioxide and water.

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(1)

(b) In a laboratory experiment, 1.45 g of propanone were burned completely in oxygen. The heat from this combustion was used to raise the temperature of 100 g of water from 293.1 K to 351.2 K.

(i) Calculate the number of moles of propanone in the 1.45 g.

(ii) Calculate the heat energy required to raise the temperature of 100 g of water from 293.1 K to 351.2 K.
(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

(iii) Hence, calculate a value, in kJ mol^{-1}, for the enthalpy of combustion of propanone.

(5)

(c) In a similar experiment, the enthalpy of combustion of butanone, C_4H_8O, was found to be –1290 kJ mol^{-1}. A data book value for the same reaction is $\Delta H_c^{\ominus}$ = –2430 kJ mol^{-1}.

(i) Suggest one reason why the experimental value is very different from the data book value.

(ii) This data book value of $\Delta H_c^{\ominus}$ for butanone (–2430 kJ mol^{-1}) refers to the formation of carbon dioxide gas and water in the gaseous state. How would this value differ if it referred to the formation of water in the liquid state? Explain your answer.

(3)

(d) Calculate a value for the standard enthalpy of formation for liquid ethanethiol, C_2H_5SH.
Use the equation given below and enthalpy of combustion data from the following table.

Substance	$C_2H_5SH(l)$	C(s)	$H_2(g)$	S(s)
$\Delta H_c^{\ominus}$ / kJ mol^{-1}	–1170	–394	–286	–297

$2C(s) + 3H_2(g) + S(s) \rightarrow C_2H_5SH(l)$

(3)

(Total 12 marks)

Q7.

Hydrogen is produced by the reaction of methane with steam. The reaction mixture reaches a state of dynamic equilibrium.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Some enthalpy data is given in the table.

Bond	C–H	O–H	H–H	C≡H
Bond enthalpy / kJ mol^{-1}	413	463	436	To be calculated

Use the information in the table and the stated enthalpy change to calculate the missing bond enthalpy.

A 234 ⬭

B 1064 ⬭

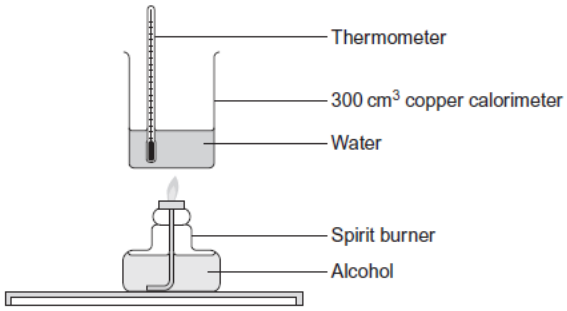
C 1476 ⬭

D 1936 ⬭

(Total 1 mark)

Q8.

A value for the enthalpy of combustion of an alcohol can be determined using the apparatus shown in the diagram. The calorimeter is held in position by a clamp.



This experiment can be repeated by using a different volume of water that would result in a more accurate value for the enthalpy of combustion because there would be a reduction in the heat lost.

State a change in the volume of water that would cause a reduction in heat loss and explain your answer.

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(Total 2 marks)

Q9.

This question is about the reaction given below.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

Enthalpy data for the reacting species are given in the table below.

Substance	CO(g)	$H_2O(g)$	$CO_2(g)$	$H_2(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	−110	−242	−394	0

The standard enthalpy change for this reaction of carbon monoxide and steam is

A +42 kJ mol^{-1}

B −42 kJ mol^{-1}

C +262 kJ mol^{-1}

D −262 kJ mol^{-1}

(Total 1 mark)