



INSIGHT

Trial Exam Paper

2011

CHEMISTRY

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes

Writing time: 1 hour 30 minutes

Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	20	20	20
B	8	8	60
			Total 80

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

Materials provided

- The question and answer book of 23 pages, with a removable data book.
- An answer sheet for multiple-choice questions.

Instructions

- Remove the data book from this book during reading time.
- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination

- Place the multiple-choice answer sheet inside the front cover of this question and answer book.

Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.

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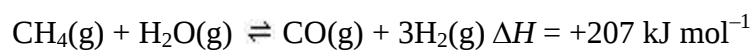
SECTION A – Multiple-choice questions**Question 1**

The energy density of methane gas in kJ g^{-1} is

- A. 0.0180
- B. 27.8
- C. 55.6
- D. 889

Question 2

Hydrogen gas is produced industrially by the following reaction



The rate at which hydrogen gas is produced would be optimised by

- A. low pressure, low temperature.
- B. low pressure, high temperature.
- C. high pressure, low temperature.
- D. high pressure, high temperature.

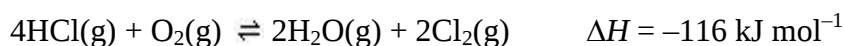
Question 3

Propane and butane can both be burned to produce heat energy. The volume of propane gas, in L, at SLC that produces the same amount of energy as 1.50 L of butane gas at SLC is

- A. 0.794
- B. 1.16
- C. 1.50
- D. 1.94

Question 4

Consider the following equilibrium system



Which of the following reaction conditions is most likely to result in the most improved rate **and** yield of reaction?

- A. excess HCl, low temperature
- B. excess O₂, high temperature
- C. addition of a catalyst, low pressure
- D. addition of a catalyst, low temperature

Question 5

A 2.00 g sample of benzoic acid, C₆H₅COOH (relative mass = 122), was used to calibrate a bomb calorimeter.

1 mol of benzoic acid releases 3227 kJ of heat energy. Complete combustion of the sample of benzoic acid resulted in the temperature of the water bath increasing from 23.10°C to 26.45°C. The calibration factor, in kJ °C⁻¹, for the calorimeter is

- A. 2.00
- B. 15.8
- C. 52.9
- D. 1.93×10^3

Question 6

Which of the following best explains the increase in reaction rate observed when a catalyst is added to a reaction mixture?

- A. Adding a catalyst increases the activation energy of the reaction, making it easier for the reaction to occur.
- B. Adding a catalyst causes the reactant particles to collide with each other more often.
- C. Adding a catalyst provides a surface to which the reactant particles can form bonds and so react with each other more easily.
- D. Adding a catalyst lowers the activation energy of the reaction, meaning the particles collide with each other more frequently.

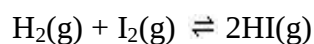
Question 7

The pH of a standard hydrogen half-cell is

- A. 0
- B. 1
- C. 7
- D. 13

Question 8

Hydrogen and iodine gas react to produce hydrogen iodide according to the equation



2.00 mol of H_2 and 1.00 mol of I_2 are added to a 2.0 L reaction vessel and allowed to reach equilibrium. If 0.500 mol of $\text{HI}(\text{g})$ is present at equilibrium, the equilibrium concentrations of $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ are

	[H₂]	[I₂]
A.	0.875	0.375
B.	1.75	0.750
C.	0.250	0.250
D.	1.00	0.500

Question 9

A mixture of $\text{N}_2\text{O}_4(\text{g})$ and $\text{NO}_2(\text{g})$ is at equilibrium according to the equation



Which of the following changes to the equilibrium mixture will result in an increase to the value of K for this reaction?

- I Doubling the volume
 - II Doubling the temperature
 - III Addition of $\text{N}_2\text{O}_4(\text{g})$
- A. I and II only
 - B. II only
 - C. I, II and III
 - D. none of the above

Question 10

Which of the following acids will show the greatest percentage ionisation in solution?

- A. boric acid
- B. hypobromous acid
- C. hydrocyanic acid
- D. lactic acid

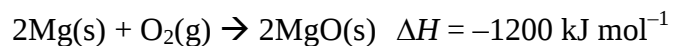
Question 11

The concentration, in mol L^{-1} , of a solution of barium hydroxide, Ba(OH)_2 , which has a pH of 11.4 is

- A. 1.99×10^{-12}
- B. 3.98×10^{-12}
- C. 1.26×10^{-3}
- D. 2.51×10^{-3}

Question 12

Magnesium reacts with oxygen according to the thermochemical equation

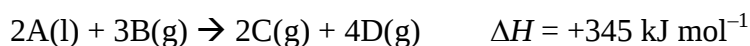


The mass, in g, of magnesium that would need to be burned to release 4000 kJ of energy is

- A. 7.29
- B. 14.6
- C. 81.0
- D. 162

Question 13

Consider the reaction system

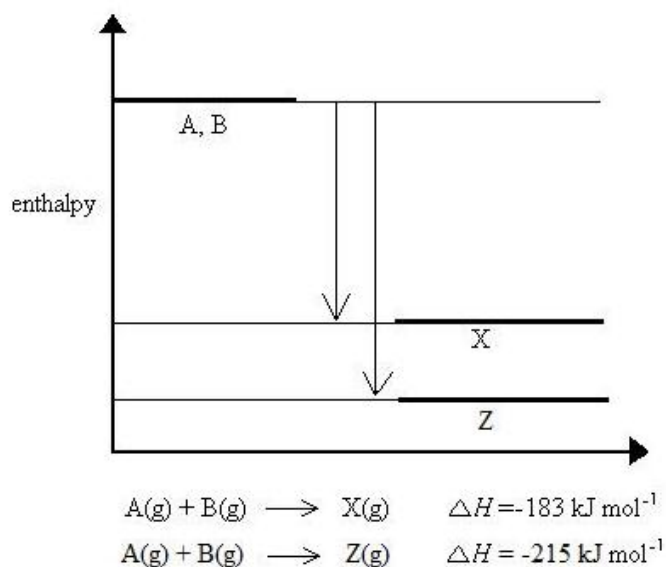


It is correct to say that for this equation

- I for each mol of A reacting, an enthalpy change of 345 kJ is produced.
 II this is an endothermic reaction.
 III the activation energy for this reaction is less than the ΔH value.
- A. I and III only
 B. II only
 C. II and III only
 D. I, II and III

Question 14

The energy diagram below relates to two reactions.



The ΔH value for the reaction $2\text{X}(\text{g}) \rightarrow 2\text{Z}(\text{g})$ will be

- A. $+32 \text{ kJ mol}^{-1}$
 B. -32 kJ mol^{-1}
 C. $+64 \text{ kJ mol}^{-1}$
 D. -64 kJ mol^{-1}

Question 15

The strongest reductant from the following list Fe^{3+} , Sn^{2+} , H_2O , K^+ , Br^- , Au , Pb^{2+} is

- A. K^+
- B. Fe^{3+}
- C. Sn^{2+}
- D. Au

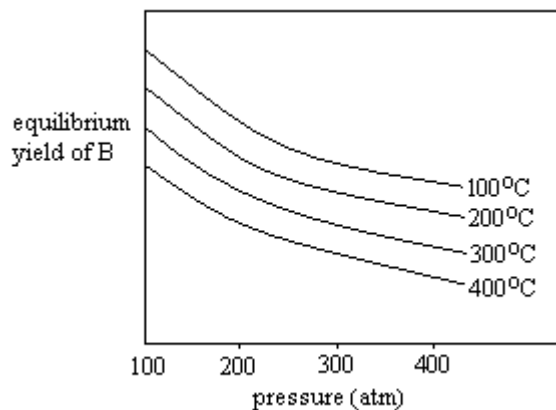
Question 16

An electric current is passed through a solution of 1.0 M KCl. The reaction that will occur at the cathode is

- A. $\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$
- B. $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
- C. $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$
- D. $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$

Question 17

Gaseous reactant A exists in equilibrium with gaseous product B. No other chemical species are present. The following graph shows the effect of increasing pressure and temperature on the equilibrium yield of product B.



Which of the following conclusions about the reaction could be correct?

- I There are more gaseous reactant particles than gaseous product particles in the equation.
 - II The reaction is exothermic.
- A. I and II only
- B. I only
- C. II only
- D. neither I nor II

Question 18

Which of the following best describes the source of energy in a nuclear power station?

- A. Nuclei are split into smaller particles and energy is released in the process.
- B. Nuclei are burnt in oxygen, releasing energy in the process.
- C. Nuclei fuse with each other to make bigger particles, releasing energy in the process.
- D. Nuclei release neutrons one at a time and release energy in the process.

Question 19

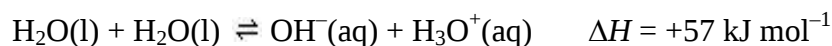
An electroplating cell is devised to place a gold coating on a brass ring. A voltage of 2.80 V and a current of 1.35 A are passed through a solution of 1.00 M Au⁺ ions, for 280 seconds.

The mass of gold produced, in grams, is closest to

- A. 0.0129
- B. 0.386
- C. 0.772
- D. 2.16

Question 20

Water self-ionises according to the equation



At 25°C the pH of pure water is 7.00. At 35°C the pH of pure water is

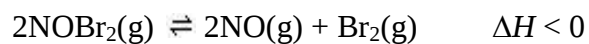
- A. 7.00 because the concentration of H₃O⁺ ions has not changed.
- B. 7.00 because although the reaction has shifted to the right, it is still neutral.
- C. less than 7.00 because the reaction has shifted to the right and the solution is now slightly acidic.
- D. less than 7.00 because the reaction has shifted to the right; however, the solution is still neutral

END OF SECTION A

**END OF SECTION A
TURN OVER**

SECTION B – Short-answer questions**Question 1**

Nitrosyl bromide (NOBr_2) decomposes according to the reaction



- a. i.** Write an equilibrium expression for this reaction.

1 mark

- ii.** 3.00 mol of NOBr_2 was added to a 4.00 L reaction vessel at 300 K. Once equilibrium was reached, 0.805 mol of Br_2 was present in the mixture. Calculate the equilibrium constant for the reaction at this temperature.

3 marks

- iii. In a second reaction mixture, also in a 4.0 L reaction vessel and at 300 K, the concentrations of the gases were found to be

$$[\text{NOBr}_2] = 0.507 \text{ M} \quad [\text{Br}_2] = 0.0405 \text{ M}$$

Calculate the concentration, in M, of NO in the reaction mixture.

2 marks

- b. Would the equilibrium yield for this reaction be favoured by a low or high temperature? Use Le Chatelier's Principle to explain your answer.

3 marks

Total 9 marks

Question 2

A student obtains four 0.10 M solutions of nitric acid, ethanoic acid, benzoic acid and sulfuric acid.

a. Calculate the pH of the

i. nitric acid solution

1 mark

ii. ethanoic acid solution

3 marks

- b. Will the molar concentration of H_3O^+ ions be the same, higher or lower in the benzoic acid solution compared to the ethanoic acid solution? Explain your answer.

2 marks

- c. List the four 0.100 M solutions in order from lowest pH to highest pH.

2 marks

- d. 100 mL of distilled water is added, separately, to the nitric acid solution and to the ethanoic acid solution.

Indicate the effect on the pH and percentage ionisation of each acid by ticking the appropriate box in the table below.

	Decrease	Increase	Not change
Effect on pH of nitric acid			
Effect on percentage ionisation of nitric acid			
Effect on pH of ethanoic acid			
Effect on percentage ionisation of ethanoic acid			

4 marks

Total 12 marks

SECTION B – continued
TURN OVER

Question 3

A bomb calorimeter can be used to determine the enthalpy changes in a chemical reaction. In one reaction, pentane is combusted in the bomb of a calorimeter that is surrounded by a 300 mL water bath.

- a.** Write a balanced thermochemical equation for the complete combustion of pentane.

2 marks

- b. i.** Calculate the mass of pentane that would need to undergo combustion in a calorimeter to produce a temperature change in the water of 1.65°C . Be sure to give your answer with the correct number of significant figures.

4 marks

- ii.** State one assumption you made when calculating your answer to **part i**.

1 mark

Total 7 marks

Question 4

During this semester, you looked at one of the following reactions as part of your study of the industrial production of an important chemical. Place a tick in the box next to the reaction that is part of the production of the chemical you studied.

	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
	$\text{C}_3\text{H}_8(\text{g}) \rightleftharpoons \text{C}_2\text{H}_4(\text{g}) + \text{CH}_4(\text{g})$
	$2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
	$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

- a. i.** What conditions of temperature and pressure favour optimum yield for your chosen reaction?

1 mark

- ii.** Are these conditions used on an industrial scale? Give a reason for your answer.

2 marks

- b. i.** Identify one specific risk to human health associated with the production of your selected chemical.

1 mark

- ii.** Give one precaution that is taken in response to the risk you identified in **part i.**

1 mark

SECTION B – Question 4 – continued
TURN OVER

- c. i. Name one useful commercial product formed from the chemical you chose.

1 mark

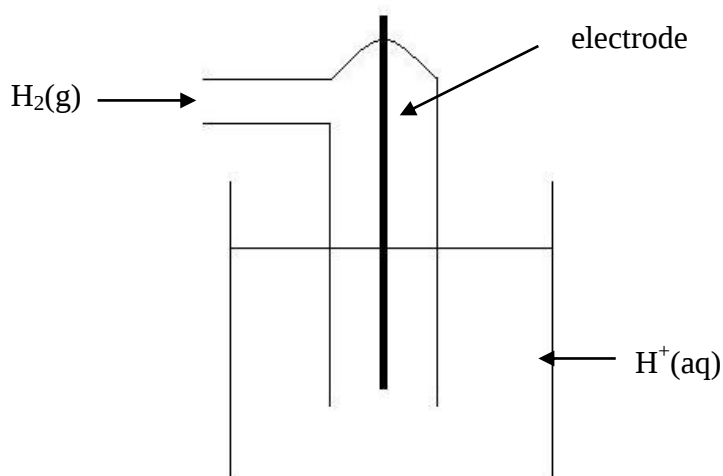
- ii. Write a chemical equation to show the formation of the commercial product named in **part c i.**

1 mark

Total 7 marks

Question 5

The $\text{H}^+(\text{aq})/\text{H}_2(\text{g})$ half-cell is the standard used to obtain the E° values listed in the electrochemical series. A diagram of the cell is shown below.



- a. State the temperature and pressure required for this cell to be used as a half-cell.

1 mark

- b. i.** After several minutes, will the pH in the $\text{H}^+(\text{aq})/\text{H}_2(\text{g})$ half-cell have increased, decreased or be unchanged?

1 mark

- ii.** Explain your answer to **part i.**

2 marks

- c. i.** Write an overall ionic equation for a galvanic cell in which one half-cell is the $\text{Fe}^{3+}(\text{aq})/\text{Fe}^{2+}(\text{aq})$ cell and which has a potential difference of 1.05 V.

1 mark

- ii.** Identify the strongest reductant in this reaction.

1 mark

Total 7 marks

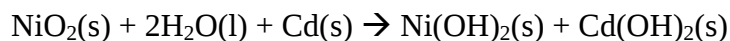
Question 6

Primary, secondary and fuel cells are all types of galvanic cells used for the production of electricity.

- a.** What is the main difference between a primary cell and a fuel cell?

1 mark

- b.** The nickel–cadmium cell is a secondary cell used to power small appliances. When the cell is being used the overall reaction is



- i.** What feature of this cell enables it to be recharged?

1 mark

- ii.** When the cell is recharging, which species is reacting at the negative electrode?

1 mark

- c.** The overall equation for a fuel cell used in ‘breathalyser’ instruments is



- i.** Write the equation for the half-reaction that occurs at the anode.

1 mark

- ii. A motorist blows into a fuel cell for 5.0 seconds and provides 1.4×10^{-4} g ethanol at the rate of 2.8×10^{-5} g per second. Calculate the maximum current, in A, that the cell would produce.

4 marks

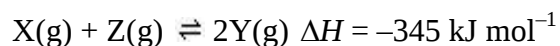
- iii. What is the energy, in kJ, that would be produced in **part c ii** if the voltage is measured at 4.0 V?

1 mark

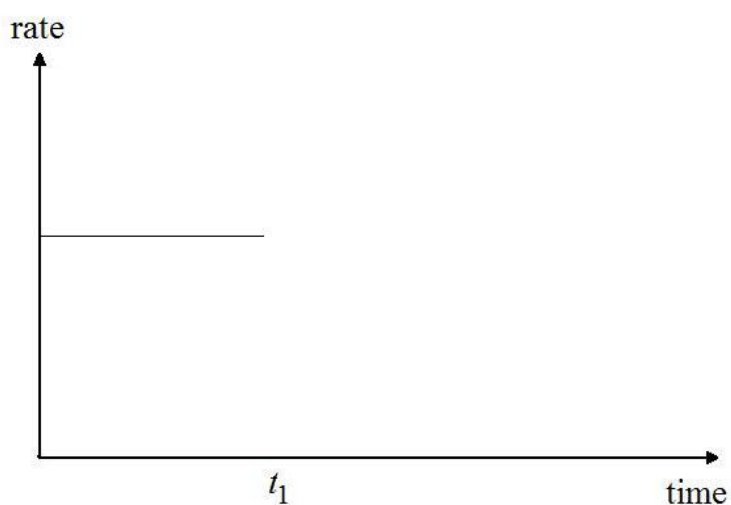
Total 9 marks

Question 7

The same amounts of reactants X and Z are placed in two sealed containers and allowed to react according to the equation

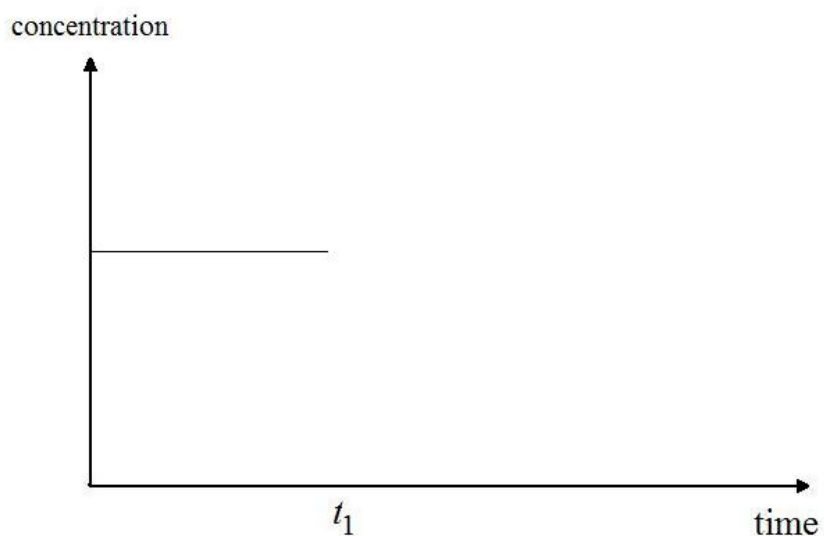


- a.** After the reaction reaches equilibrium in container 1, a small amount of catalyst is added to the container at time t_1 .
- i.** On the rate–time graph below, continue the line to show what will happen to the rate of the forward reaction after time t_1 in container 1.



1 mark

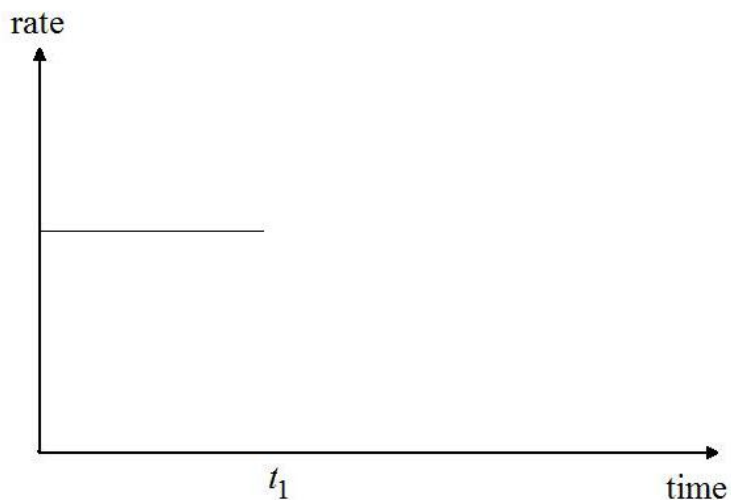
- ii.** On the concentration–time graph below, continue the line to show what will happen to the concentration of reactant X after time t_1 in container 1.



1 mark

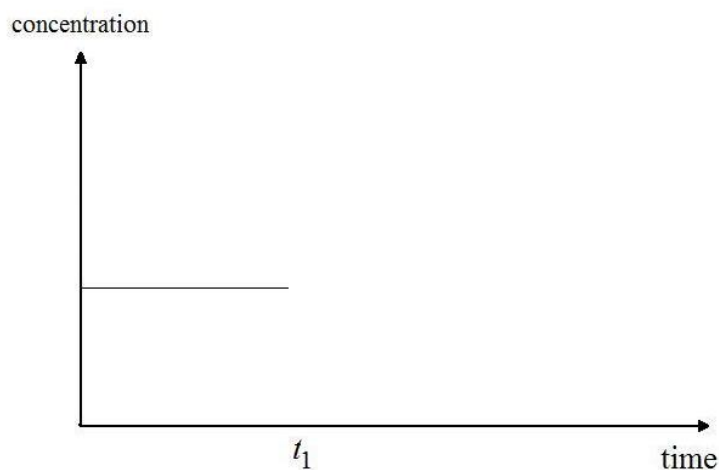
- b.** After the reaction reaches equilibrium in container 2, the volume of the reaction vessel is halved at time t_1 .

- i.** On the rate–time graph below, continue the line to show what will happen to the rate of the forward reaction after time t_1 in container 2.



1 mark

- ii.** On the concentration–time graph below, continue the line to show what will happen to the concentration of reactant X at time t_1 in container 2.



2 marks

iii. Explain the graph you drew in **part i**.

1 mark

Total 6 marks

Question 8

A panel of experts is making recommendations to a government group regarding future choices for energy sources. The experts have been comparing the energy sources brown coal, natural gas, nuclear fission and ethanol (a biochemical fuel).

a. Which energy source would you recommend on the basis of sustainability? Give a reason for your answer.

1 mark

b. Which energy source would you recommend on the basis of energy density; that is, which fuel has the highest kJ g^{-1} ?

1 mark

- c. Which **two** energy sources would you recommend as producing the least amount of greenhouse gas emissions per gram? Explain your answer.

2 marks

Total 4 marks

END OF SECTION B
END OF QUESTION AND ANSWER BOOK