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Student name

CHEMISTRY
Unit 4
Trial Examination

QUESTION AND ANSWER BOOK

Total writing time: 1 hour 30 minutes

Structure of book

Section	Number of questions	Number of marks
A	20	20
B	8	58
	Total	**78**

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape, mobile phones and/or any other unauthorised electronic devices.
- A copy of the official VCAA Data Book (printed or photocopied) can be brought into the trial examination.

Materials supplied

- Question and answer book of 14 pages, with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions

- Detach the answer sheet for multiple-choice questions during reading time.
- Write your **name** in the space provided above on this page and on the answer sheet for multiple-choice questions.
- All written responses should be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep your copy of the VCAA Data Book.

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2010

CHEMISTRY

Unit 4 Trial Examination

MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	

INSTRUCTIONS: **USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

	ONE ANSWER PER LINE					ONE ANSWER PER LINE				
1	A	B	C	D	11	A	B	C	D	
2	A	B	C	D	12	A	B	C	D	
3	A	B	C	D	13	A	B	C	D	
4	A	B	C	D	14	A	B	C	D	
5	A	B	C	D	15	A	B	C	D	
6	A	B	C	D	16	A	B	C	D	
7	A	B	C	D	17	A	B	C	D	
8	A	B	C	D	18	A	B	C	D	
9	A	B	C	D	19	A	B	C	D	
10	A	B	C	D	20	A	B	C	D	

SECTION A – Multiple-choice questions

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.
Choose 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 mark will be given if more than one answer is completed for any question.

Question 1

Addition of a catalyst increases the rate of reaction because the catalyst decreases the

A. energy released or absorbed during a reaction.

B. enthalpy of the products of a reaction.

C. number of fruitful collisions between reactant particles.

D. energy required to break bonds in the reactants.

Question 2

In the mining industry, insoluble nickel (II) oxide obtained from roasting nickel ores, can be dissolved in dilute sulfuric acid according to the equation

$$NiO(s) + H_2SO_4(aq) \rightarrow NiSO_4(aq) + H_2O(l)$$

The rate of reaction may be measured by monitoring the time taken for the green colour of nickel(II) ions to reach a defined intensity. Which of the following would lead to an increase in the time taken for the colour of the solution to reach a defined intensity?

A. using the same volume of a more concentrated sulfuric acid solution.

B. heating the sulfuric acid solution before adding nickel (II) oxide.

C. grinding the nickel (II) oxide into a fine powder before adding it to the sulfuric acid solution.

D. using twice the volume of the same concentration of sulfuric acid solution.

Questions 3 and 4 refer to the following information.

A mixture of ethene gas and hydrogen gas was allowed to react in a sealed, 500 mL flask. The equilibrium that resulted may be represented as: $C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$

At equilibrium, there was found to be 1.25×10^{-1} mol of $C_2H_6(g)$, 7.50×10^{-2} mol of $C_2H_4(g)$ and 8.35×10^{-2} mol of $H_2(g)$ present in the flask.

Question 3

The equilibrium constant for this reaction under these conditions is

A. $0.0501\ M^{-1}$

B. $0.100\ M^{-1}$

C. $9.98\ M^{-1}$

D. $20.0\ M^{-1}$

Question 4

Which one of the following would result in a change in the value of the equilibrium constant for this reaction?

A. Increasing the concentration of $C_2H_4(g)$.

B. Adding a catalyst.

C. Decreasing the temperature of the reaction flask.

D. Increasing the pressure in the flask.

Question 5

A step in the production of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide according to the equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_2(g) \quad \Delta H = -197 \text{ kJ mol}^{-1}$$

The pressure in the catalytic converter where this reaction takes place is maintained at approximately 1 atmosphere. A higher pressure would result in

A. a higher equilibrium yield of sulfur trioxide and a faster rate of reaction.

B. a higher equilibrium yield of sulfur trioxide and a slower rate of reaction.

C. a lower equilibrium yield of sulfur trioxide and a faster rate of reaction.

D. a lower equilibrium yield of sulfur trioxide and a slower rate of reaction.

Question 6

A solution of ammonia is diluted. As a result, the change to pH and % ionisation respectively is

A. increased, increased

B. increased, decreased

C. decreased, increased

D. decreased, decreased

Question 7

A solution of sodium hydroxide has a pH of 10. It is diluted by taking 1.0 mL of the solution and diluting to 100 mL with deionised water. The pH of the resulting solution will be

A. 8

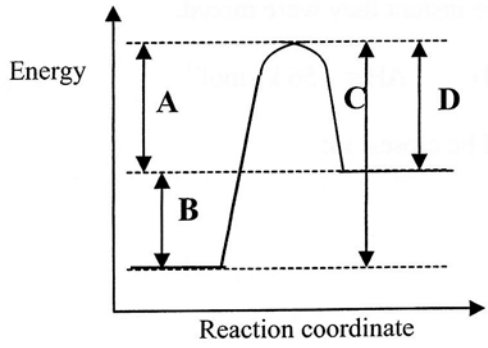
B. 9

C. 11

D. 12

Question 8

The diagram shows the energy changes occurring during a chemical reaction.



According to the diagram, the letter representing the energy change during the formation of new bonds in the forward reaction is

A. energy change A.

B. energy change B.

C. energy change C.

D. energy change D.

Question 9

When 5.00 g of phosphorus is burned at 1.00 atmosphere pressure in gaseous chlorine, according to the given equation, 98.7 kJ of heat energy is released to the surroundings.

$$2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(g)$$

The enthalpy change, ΔH, for this reaction is closest to

A. $-98.7\ kJ\ mol^{-1}$

B. $-6.12 \times 10^2\ kJ\ mol^{-1}$

C. $+6.12 \times 10^2\ kJ\ mol^{-1}$

D. $-1.22 \times 10^3\ kJ\ mol^{-1}$

Question 10

When solid NH_4NO_3 dissolves in water the temperature of the mixture drops. The process is

A. endothermic and ΔH is negative.

B. endothermic and ΔH is positive.

C. exothermic and ΔH is negative.

D. exothermic and ΔH is positive.

Question 11

300 mL of 2.0 M HCl is mixed with 200 mL of 2.0 M KOH in a thermally insulated container. The temperature of the solutions was 20°C at the instant they were mixed.

Given that $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ $\Delta H = -56$ kJ mol^{-1}

The final temperature of the mixture would be closest to:

A. 30°C

B. 35°C

C. 40°C

D. 45°C

Question 12

For the reaction: $H_2(g) + X_2(g) \rightarrow 2HX(g)$ $\Delta H = -110$ kJ mol^{-1}

ΔH for the reaction: $HX(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}X_2(g)$ is

A. -220 kJ mol^{-1}

B. -55 kJ mol^{-1}

C. + 55 kJ mol^{-1}

D. + 110 kJ mol^{-1}

Question 13

A galvanic cell can be constructed by linking a standard hydrogen half-cell to a standard Ni^{2+}/Ni half-cell. In this galvanic cell

A. the concentration of nickel (II) ions would decrease

B. reduction would occur at the platinum electrode

C. the pH of the solution in the standard hydrogen half-cell would decrease

D. hydrogen gas would be consumed at the anode.

Questions 14 and 15 refer to the following information

Methanol can be used as a liquid in a compact and portable fuel cell which uses alkaline electrolyte to provide energy. The overall equation for the combustion of methanol is:

$$2CH_3OH(l) + 3O_2(g) \rightarrow CO_2(g) + 4H_2O(g)$$

Question 14

Which of the following best describes the reaction occurring at the cathode in this fuel cell?

A. $CH_3OH(l) + 6OH^-(aq) \rightarrow CO_2(g) + 5H_2O(g) + 6e^-$

B. $O_2(g) + 2H_2O(g) + 4e^- \rightarrow 4OH^-(aq)$

C. $CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$

D. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

Question 15

During the operation of the fuel cell, the pH of the solution near the cathode would

A. increase as OH^- is produced.

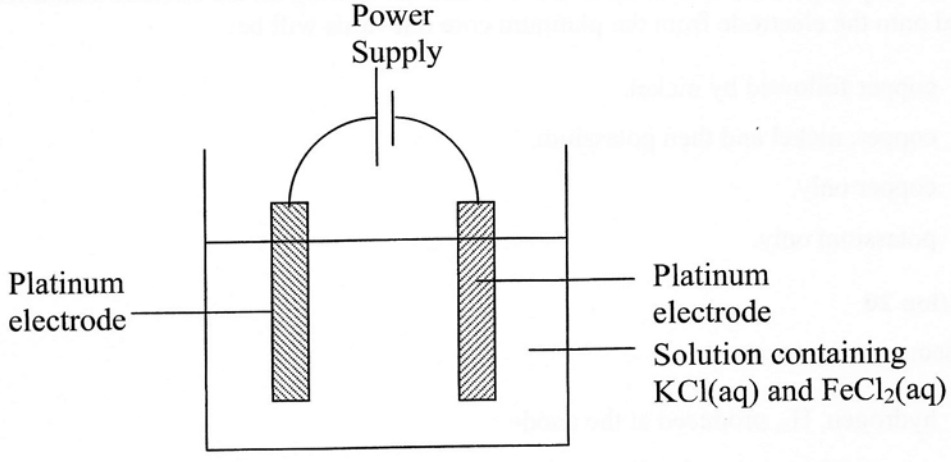
B. decrease as OH^- is used up.

C. decrease as H^+ is produced.

D. increase as H^+ is used up.

Question 16

The diagram represents an experimental arrangement used by a student to investigate the electrolysis of a mixture containing two metal chlorides. The solution contains; 0.010 M KCl and 0.010 M $FeCl_2$. The student carefully increased the voltage until electrolysis begins.



The product at the **anode** is most likely to be

A. potassium metal.

B. iron(III) ions.

C. oxygen gas.

D. iron metal.

Question 17

A 1.0 M aqueous solution of potassium nitrate was electrolysed using inert electrodes. In this electrolysis, water acts as

A. a solvent only.

B. an oxidant and as a solvent.

C. an reductant and as a solvent.

D. both oxidant and reductant, and as a solvent.

Question 18

When a direct current of electricity is conducted by an aqueous solution of an electrolyte in an electrolytic cell

A. the movement of electrons accounts for the current flow through the solution.

B. the solution remains electrically neutral.

C. electrons always flow towards the positive electrode.

D. the number of positive ions moving toward one electrode is always equal to the number of negative ions moving toward the other electrode.

Questions 19 and 20 refer to the following information.

A solution containing a mixture of 1.0 M KNO_3, 1.0 M $Ni(NO_3)_2$ and 1.0 M $Cu(NO_3)_2$ is electrolysed using platinum electrodes. The voltage is increased in steps of 0.5 V and observations are made after each increment until eventually only gaseous products are observed at both electrodes.

Question 19

The electrolytic process was stopped at 2.0 V and the coating on the cathode examined. The materials coated onto the electrode from the platinum core outwards will be:

A. copper followed by nickel.

B. copper, nickel and then potassium.

C. copper only.

D. potassium only.

Question 20

A gaseous product was:

A. hydrogen, H_2, produced at the anode.

B. oxygen, O_2, produced at the anode.

C. nitrogen, N_2, produced at the cathode.

D. nitrogen (IV) oxide, NO_2, is produced at the cathode.

END OF SECTION A

SECTION B – Short answer questions

Instructions for Section B

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

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for 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

A weak acid can be represented by the formula HX. Its ionisation in aqueous solution can be represented as

$$HX(aq) + H_2O(l) \rightleftharpoons X^-(aq) + H_3O^+(aq)$$

A solution of the acid was prepared by dissolving 5.00×10^{-3} mol of the acid in 100 mL of deionised water. 3.5 % of this acid was found to have ionised.

a. **i.** Write a general expression to represent the % ionisation of the acid HX.

_____

_____

_____

ii. Determine the pH of the solution.

_____

_____

_____

3 marks

b. Calculate the K_a value for this weak acid.

_____

_____

1 mark

c. If 0.0010 mol of the potassium salt, KX, was added to the acid solution, what change (increase/decrease/no change) in pH would occur? Justify your response.

_____

_____

_____

2 marks

Total 6 marks

Question 2

Ammonia is produced commercially in the Haber process. One step in this process is the equilibrium reaction shown in the equation

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -91 \text{ kJ mol}^{-1}$$

a. What does the term 'equilibrium' mean in terms of the

i. rate of reaction

_____

_____

ii. concentration of reactants and products?

_____

_____

2 marks

b. Write down the expression and unit for the equilibrium constant for this reaction.

_____

_____

2 marks

c. A student attempted to simulate the Haber process reaction by allowing a mixture of the reactant gases to come to equilibrium in a 2.00 L vessel at 25°C. The following concentrations were determined:
$[N_2] = 0.040$ M, $[H_2] = 0.10$ M and $[NH_3] = 0.00200$ M
Calculate the equilibrium constant for the equilibrium system at 25°C.

_____

_____

1 mark

d. **i.** State Le Chatelier's principle.

_____

_____

_____

ii. If the simulation was carried out at 40°C, predict the effect on the equilibrium yield and explain your response with reference to Le Chatelier's principle.

_____

_____

_____

3 marks
Total 8 marks

Question 3

In the manufacture of ammonia, hydrogen can be obtained from natural gas by a reaction with steam:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206.1 \text{ kJ mol}^{-1}$$

a. Write an expression for the K_c for this reaction.

_____

_____

_____

1 mark

b. For each of the changes below, say what will happen to the K_c and explain why.

i. the temperature is increased

_____

_____

ii. volume is decreased

_____

_____

iii. a catalyst is used

_____

_____

3 marks

c. How will the composition of the equilibrium mixture be affected by

i. increasing the pressure

_____

_____

ii. increasing the temperature

_____

_____

iii. using a catalyst

_____

_____

3 marks

Total 7 marks

Question 4

Many biological systems are pH controlled (buffered) by a mixture of dihydrogenphosphate and hydrogen phosphate ions

$$H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq) \quad K_a = 6.2 \times 10^{-8}\ M$$

a. Write the acidity constant expression for this equilibrium.

_____

_____

1 mark

b. Predict qualitatively, giving your reasoning, how the pH of a solution containing equal concentrations of these ions will behave on adding a few drops of

i. dilute hydrochloric acid

_____

_____

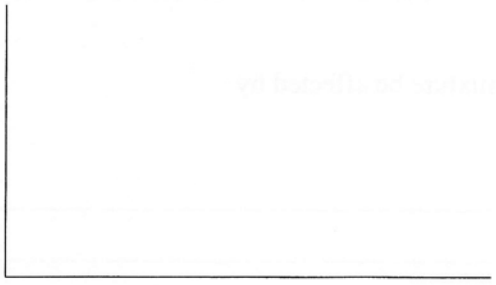
ii. dilute sodium hydroxide

_____

_____

2 marks

c. Draw a graph of pH vs time to depict the change in pH over time with the addition of dilute sodium hydroxide from **b ii.** above.



1 mark

d. Suppose the pH of the equilibrium mixture is required to be 6.9. What concentration of $HPO_4^{2-}(aq)$ would be needed in a solution that is already 0.100 M $H_2PO_4^-(aq)$?

_____

_____

_____

1 mark

Total 5 marks

Question 5

a. Predict whether a reaction is possible between the following pairs under standard conditions and explain your prediction. If a reaction occurs write the expected balanced equation.

i. $Fe^{2+}(aq)$ and $I_2(s)$

_____

_____

ii. $Sn^{2+}(aq)$ and $I_2(s)$

_____

_____

iii. oxygenated water and Zn

_____

_____

2 marks

b. Despite reaction being expected, sometimes it is not seen. Explain why.

_____

_____

1 mark

Total 7 marks

Question 6

One way in which we might be able to use the energy which plants store as cellulose and starch would involve first their chemical conversion to glucose, $C_6H_{12}O_6$. Glucose might then be a suitable fuel for a fuel cell using acid electrolyte.

The overall equation for this fuel cell is $C_6H_{12}O_6\,(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

a. Write the oxidation half-equation for this fuel cell.

_____

2 marks

b. Given that the half-cell potential for the reaction occurring at the anode is + 0.01V, calculate the cell potential.

_____

1 mark

c. How much energy could the cell provide under standard conditions per mole of glucose?

_____

_____

3 marks

d. How much energy can the cell provide using a teaspoon of glucose i.e. 5.0 g?

_____

_____

1 mark

Total 7 marks

Question 7

A steel can may be plated with tin by electrolysis in an aqueous solution containing tin ions.
The equation for the plating can be represented as $Sn^{n+}(aq) + ne^- \rightarrow Sn(s)$

a. Sketch a diagram of the apparatus that could be used to electroplate tin, labelling the

i. polarity of the steel can in the circuit

ii. direction of electron flow

iii. the electrolyte and give its chemical composition

3 marks

b. The following data was obtained from such an electroplating experiment:

Volume of tin plate	= 0.41 mL
Density of tin	= 7.30 g mL^{-1}
Average Current	= 3.25 A
Time	= 25.0 min

Calculate the charge on the tin ion used in the electrolyte.

4 marks

Total 7 marks

Question 8

A strategy to counter CO_2 emissions and reduce the greenhouse effect is to use fuels that provide a better CO_2 efficiency. This efficiency can be calculated as shown below.

$$CO_2 \text{ efficiency} = \frac{\text{energy released in kJ per kg of fuel}}{CO_2 \text{ emission in g per kg of fuel}}$$

Consider the fuels methane CH_4 and ethanol CH_3CH_2OH.

a. Calculate the energy released, in kJ per kg, of

i. methane

_____

_____

ii. ethanol

_____

_____

4 marks

b. Calculate the mass, in g, of CO_2 emitted per kg of

i. methane

_____

_____

ii. ethanol

_____

_____

4 marks

c. **Calculate** the CO_2 efficiency for the two fuels and **state** which would be more efficient in reducing greenhouse gases.

_____

_____

_____

2 marks

d. Other than cost, state another factor that would be considered when selecting between the suitability of ethanol and methane as a fuel.

_____

1 mark

Total 11 marks

END OF EXAMINATION