VCE CHEMISTRY 2011

YEAR 12 TRIAL EXAM UNIT 4

Time allowed: 90 Minutes
Total marks: 85

Section A
Contains 20 Multiple Choice Questions
20 marks, 21 minutes

Section B
Contains 6 Short Answer Questions
65 marks, 69 minutes

To download the Chemistry Data Book please visit the VCAA website:
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf *Page 20*

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Student Name....………………………...

VCE Chemistry 2011 Year 12 Trial Exam Unit 4

Student Answer Sheet

There are 20 Multiple Choice questions to be answered by circling the correct letter in the table below. Use only a 2B pencil. If you make a mistake, erase and enter the correct answer. Marks will not be deducted for incorrect answers

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

VCE Chemistry 2011 Year 12 Trial Exam Unit 4

SECTION A – Multiple Choice Questions

Section A consists of 20 multiple-choice questions.
Section A is worth approximately 24 per cent of the marks available.
Choose the response that is **correct** *or* **best answers** *the question.*
Indicate your choice on the answer sheet provided.

Question 1

A solution calorimeter containing 100 mL of water was calibrated using electrical apparatus. The calorimeter constant was calculated to be 560 J K^{-1}. This calorimeter constant suggests that

A. the calorimeter was well insulated.
B. the temperature change in the calorimeter was too high because the thermometer was in contact with the heating element.
C. the calorimeter actually contained only 80 mL of water.
D. the temperature change was not converted from °C to K prior to calculating the calibration factor.

Question 2

When aqueous solutions of iron(III) nitrate, $Fe(NO_3)_3$, and potassium thiocyanate, KSCN, are mixed together, a deep red colour, characteristic of the thiocyanatoiron(III) ion, $Fe(NCS)^{2+}$(aq), forms, courtesy of the equilibrium $Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons Fe(NCS)^{2+}(aq)$.

If a 10 mL sample of this equilibrium mixture is diluted by the addition of 10 mL of water

A. the $[Fe(NCS)^{2+}]$ will decrease, but the amount present will increase as the system returns to equilibrium.
B. the equilibrium constant is lowered by the addition of water, and more $Fe(NCS)^{2+}$(aq) is produced as the system moves to increase the equilibrium constant.
C. the $[Fe^{3+}]$ will decrease, but the amount present will increase as the system moves back to equilibrium.
D. the $[Fe^{3+}]$ and $[SCN^-]$ will both be higher when a new equilibrium is established after the addition of the water.

Question 3

When NO(g) reacts with O_2(g) to produce NO_2(g), equilibrium is established, according to

$$NO(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons NO_2(g);\ \Delta H = -57.0\ \text{kJ mol}^{-1}$$

At 200ºC, the equilibrium constant has the value 843 $M^{-1/2}$

Which of the following is correct for the equilibrium

$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$ at 200º C?

A. ΔH = -114 kJ mol^{-1}
B. $K = 1.41 \times 10^{-6}$
C. $\Delta H = 3.25 \times 10^{3}$ kJ mol^{-1}
D. $K = 1.69 \times 10^{3}$

Question 4

In the absence of oxygen, bacteria may derive energy by causing a reaction between nitrate ions and glucose in organic matter, according to the equation

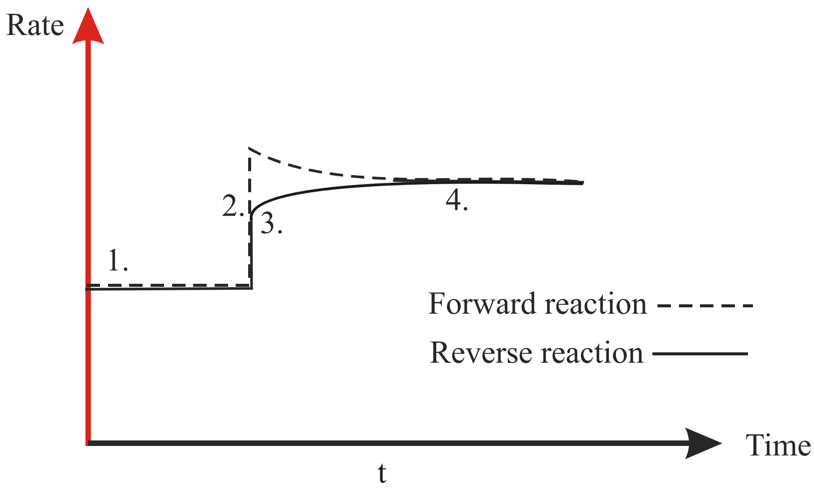
$5C_6H_{12}O_6(s) + 24NO_3^-(aq) \rightarrow 30CO_2(g) + 18H_2O(l) + 24OH^-(aq) + 12N_2(g)$; $\Delta H = -11\ 925$ kJ mol^{-1}

The maximum amount of energy available from 1 mole of glucose in this reaction is

A. the same as from the combustion of 1 mole of glucose.
B. greater than from the combustion of 1 mole of glucose.
C. less than from the combustion of 1 mole of glucose.
D. 11 925 kJ.

Questions 5 and 6 refer to the following information.

The diagram below shows rate-time graphs for an equilibrium reaction.



Question 5

The change in the rates at time **t** could be due to

A. the addition of more reactant(s).
B. a temperature decrease.
C. the removal of some product(s).
D. a volume decrease.

Question 6

To which of the following equilibria could the above rate–time graphs apply?

A. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
B. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
C. $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$
D. $C_4H_{10}(g) \rightleftharpoons C_2H_4(g) + C_2H_6(g)$

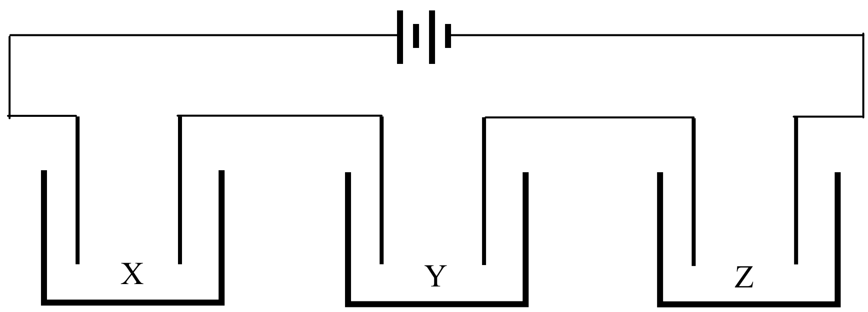
Question 7
The iron(II) ion, $Fe^{2+}(aq)$
A. can act as an oxidant but not a reductant.
B. can oxidise solid zinc and reduce liquid bromine.
C. can act as a reductant but not an oxidant.
D. will always be reduced to Fe(s) in redox reactions.

Question 8
Silver oxide – zinc cells have been used as hearing-aid batteries and as sources of constant voltage in scientific equipment. They are characterised by the cell reaction

$$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$$

The **change** in oxidation number occurring at the positive electrode when this cell is discharging is
A. -1
B. +1
C. -2
D. +2

Question 9
A current of 2.5 A is passed for 50 minutes through three cells, X, Y and Z, containing 1 molar solutions of ionic compounds and connected in series.



In two of the cells, a gas is evolved at the (-) electrode, whereas in the other cell a solid collects on the (-) electrode.
The solutions in the cells X, Y and Z may have been
A. $Al(NO_3)_3(aq)$, $KBr(aq)$, $LiNO_3(aq)$
B. $CoCl_2(aq)$, $CuCl_2(aq)$, $CaCl_2(aq)$
C. $MgCl_2(aq)$, $NiCl_2(aq)$, $KCl(aq)$
D. $AgNO_3(aq)$, $SnCl_2(aq)$, $LiCl_2(aq)$

Question 10
Calcium hydroxide, $Ca(OH)_2$, is sparingly soluble in water. An aqueous solution of calcium hydroxide has a pH of 10.0 at 25°C.
The concentration, in mol L^{-1}, of $Ca(OH)_2$, in the solution is
A. 0.00005
B. 0.0001
C. 2×10^{-10}
D. 1×10^{-10}

Question 11

The weak acid HA(aq) ionises according to the equilibrium

$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$

The ratio [HA] / [A^-] in a specific weak acid was measured as a function of the pH at equilibrium at 25°C. The following data were recorded.

[HA] / [A^-]	**pH**
1.32×10^4	4.5

The weak acid was

A. ethanoic acid.
B. methanoic acid.
C. hypochlorous acid.
D. hypobromous acid.

Question 12

One kilojoule of energy

A. is the energy needed to raise the temperature of one kg of water by one degree.
B. is associated with the flow of a current of one ampere for 1000 seconds at a potential difference of one volt.
C. is produced when 2 g H_2 burns in oxygen.
D. is required for the production of 1 mol of H_2 by electrolysis of water.

Question 13

Ammonia is a weak base, which ionises in water according to the equation

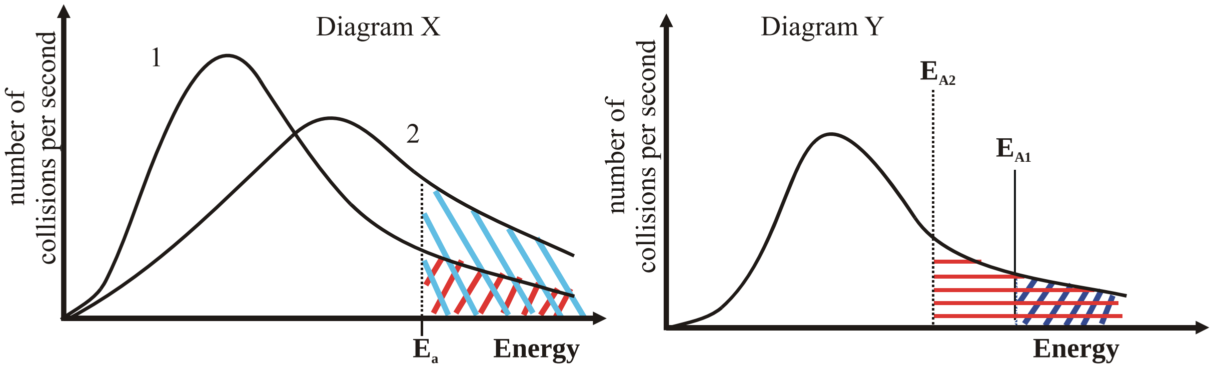
$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq).$$

If 50 mL of water is added to 50 mL of 0.20 M NH_3(aq), which of the following correctly describes the expected change in pH of the solution, and percentage ionisation of NH_3, due to the dilution.

A. pH increases, percentage ionisation increases.
B. pH decreases, percentage ionisation increases.
C. pH increases, percentage ionisation decreases.
D. pH decreases, percentage ionisation decreases.

Question 14

Diagrams X and Y below show, in graphical form, the number of molecular collisions per second against collision energy, for two different factors that influence reaction rate.



The factors represented in each diagram are

A. X – concentration, Y – use of a catalyst.
B. X – use of a catalyst, Y – temperature.
C. X – temperature, Y – pressure.
D. X – temperature, Y – use of a catalyst.

Question 15

Consider the equilibrium: $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = -113 \text{ kJ mol}^{-1}$

A piston contains an equilibrium mixture of $NO(g)$, $O_2(g)$ and $NO_2(g)$ at 300°C.
Which one of the following changes would **not** increase the amount of NO_2 in the equilibrium mixture when equilibrium is re-established after the change?

A. Decreasing the temperature to 200°C.
B. Decreasing the volume of the system at constant temperature.
C. Adding nitrogen gas at constant volume.
D. Adding air at constant volume.

Question 16

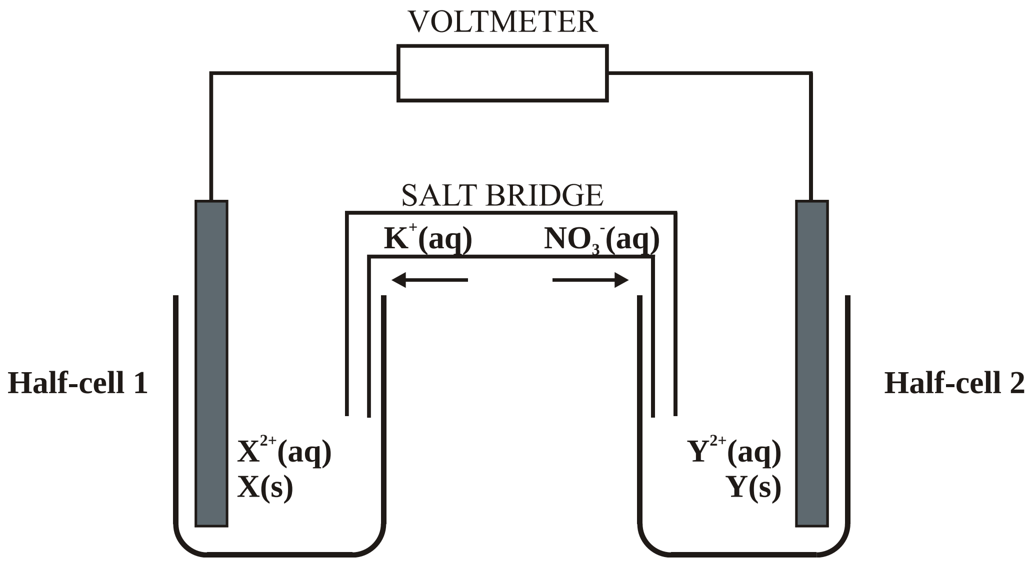
Ammonia and chlorine gas react according to the equilibrium equation

$$NH_3(g) + 3Cl_2(g) \rightleftharpoons NCl_3(g) + 3HCl(g)$$

In an experimental investigation, a mixture of 3 mol NH_3 and 10 mol Cl_2 is allowed to reach equilibrium. The amount of NCl_3 present in the equilibrium mixture is **most likely** to be

A. 2 mol
B. 3 mol
C. 10 mol
D. 13 mol

Question 17
Consider the galvanic cell represented below.



Which of the following deductions about this cell is correct?

A. Oxidation is occurring in half-cell 2.
B. The positive electrode is in half-cell 2.
C. Oxidation is occurring in half-cell 1.
D. The negative electrode is in half-cell 1.

Question 18
When a sample of pure octane undergoes complete combustion at 100 % efficiency, 200 MJ of energy is released at SLC. What was the mass of the octane sample?

A. 4.17 g
B. 4.17 kg
C. 36.6 g
D. 36.6 kg

Question 19
The half-equation for the reaction occurring at the (+) electrode in a hydrogen-oxygen fuel which has an alkaline electrolyte would be

A. $H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$
B. $H_2(g) \rightarrow 2H^+(g) + 2e^-$
C. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
D. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Question 20

Consider the thermochemical equations

$$N_2O_4(g) \rightarrow 2NO_2(g); \qquad \Delta H = +57.9 \text{ kJ mol}^{-1}$$

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g); \qquad \Delta H = -113.1 \text{ kJ mol}^{-1}$$

On the basis of this information ΔH for the reaction

$$2NO(g) + O_2(g) \rightarrow N_2O_4(g)$$

would be

A. -55.2 kJ mol^{-1}
B. +55.2 kJ mol^{-1}
C. -171 kJ mol^{-1}
D. +171 kJ mol^{-1}

End of Section A

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SECTION B – Short Answer Question

Section B consists of 6 short answer questions.
You should answer all of these questions.
This section is worth approximately 66 per cent of the total marks available.
The marks allotted are shown at the end of each part of each question.
Questions should be answered in the spaces provided.

Question 1

Many chemical reactions do not proceed to completion. Actual product yields lower than those theoretically calculated on the basis of a complete reaction, are quite common. Reactions that do not proceed to completion reach chemical equilibrium.
In Unit 4 you were required to study the industrial production of one of the following chemicals: ammonia, ethene, sulphuric acid or nitric acid.

a. Write the chemical formula of the chemical you studied.

(1 mark)

b. i. Write a balanced equation for an equilibrium reaction associated with the 'industrial production of the selected chemical' which you studied in this unit.

(1 mark)

ii. When the reactants involved in this reaction are added to a reaction vessel, what condition is necessary for reaction to commence?

(1 mark)

iii. Explain **how**, once reaction has commenced, it eventually reaches equilibrium?

(4 marks)

iv. For each of the following changes to the equilibrium reaction, state the effect on the position of equilibrium, i.e. moves left *or* moves right *or* no effect.

Increasing pressure ________________________________

Decreasing temperature ______________________________

(2 marks)

c. Write a balanced equation for the reaction that occurs between your selected chemical and water.

(1 mark)

Total 10 marks

Question 2

A key chemical characteristic of fuel cells is that the overall reaction is the same as the combustion reaction of the fuel which is used in the cell.

a. Write a balanced equation for the combustion of methane.

(1 mark)

b. What is the main energy transformation occurring in an operating fuel cell?

(1 mark)

c. Why are fuel cells more efficient than conventional chemical fuel fired power stations?

(1 mark)

Types of fuel cell are usually characterised by their electrolyte, temperature of operation, transported ion and fuel. In the March 2011 edition of 'Technology Review' published by MIT the following description was given of Solid Oxide Fuel Cells (SOFC).

Solid-oxide fuel cells, which can run a variety of fuels including diesel or natural gas, bring in oxygen from the air to be reduced at the cathode, and then pass the oxygen [oxide] ions through a solid-oxide electrolyte membrane to the anode, where the fuel is oxidized to produce electrons that are drawn out of the device. Their high operating temperatures are dictated by the fact that the ions move more quickly through the electrolyte at higher temperatures (500-1000 °C).

d. Assuming the fuel used in an SOFC is methane, write balanced half-equations for the reactions at

i. the (-) electrode

(1 mark)

ii. the (+) electrode

(1 mark)

e. Why could the operating voltage of a SOFC not be accurately predicted from a standard electrochemical series?

(1 mark)

Another type of fuel cell is the Polymer Electrolyte Membrane Fuel Cell (PEMFC). This fuel cell uses hydrogen as its fuel, operates between 20°C and 80°C, and the membrane only allows the conduction of cations.

f. Write half-equations for the reactions occurring at

i. the anode

(1 mark)

ii. the cathode

(1 mark)

g. Write a balanced equation for the overall PEMFC reaction.

(1 mark)

Total 9 marks

Question 3

Methanoic acid, HCOOH, is a weak acid. An 18.5 mL sample of an aqueous solution of methanoic acid required 17.25 mL of 0.155 M NaOH to reach the endpoint in a titration.

a. Calculate the amount, in mole, of methanoic acid in the sample.

(1 mark)

b. i. Write the equilibrium law associated with an aqueous solution of methanoic acid.

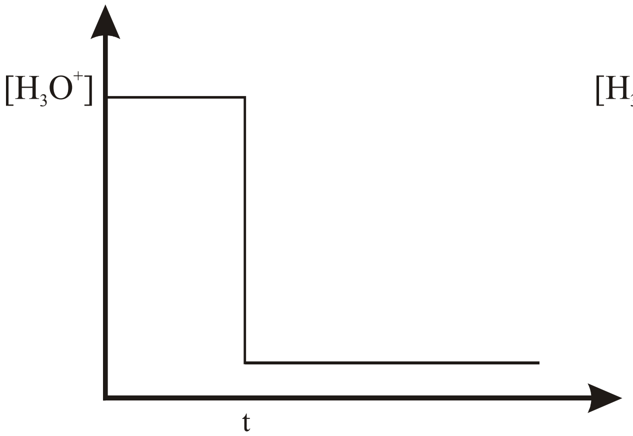
(1 mark)

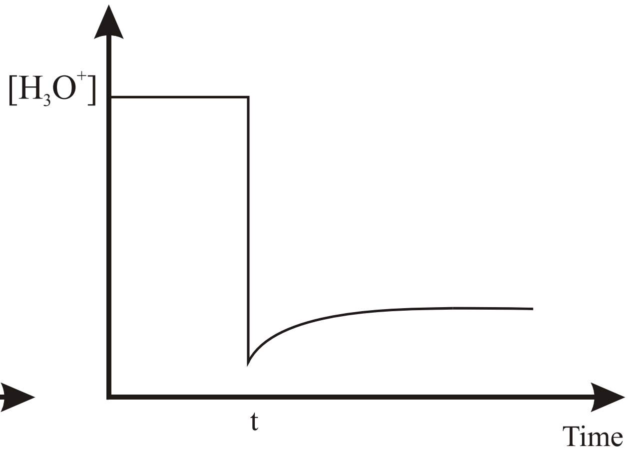
ii. Calculate the pH of the methanoic acid solution.

(4 marks)

c. A 10 mL sample of this methanoic acid solution was diluted to 100 mL with water.

i. Which of the graphs shown below best represents the change in $[H_3O^+]$ as a result of this dilution? Circle your chosen graph.





Explain the shape of your chosen graph.

(2 marks)

ii. What does the graph chosen in (i) indicate about the effect of dilution on the pH of an aqueous solution of methanoic acid?

(2 marks)

iii. In terms of the dilution of an acid, what does the other graph represent?

(1 mark)

Total 11 marks

Question 4

The energy content of olive oil was determined by bomb calorimetry. The procedure followed is described in the flowchart below.

0.853 g of ethanol was placed in the reaction bomb in the bomb calorimeter

↓

Excess oxygen is pumped into the bomb calorimeter → Temperature of the water in the calorimeter is 21.30 °C.

↓

The mixture in the calorimeter is sparked and the ethanol completely reacted with oxygen → Temperature of the water after the reaction is 24.10 °C.

↓

The reaction bomb is removed from the calorimeter and cleaned, then 1.00 g of olive oil was placed in the reaction bomb

↓

Excess oxygen is pumped into the bomb calorimeter → Temperature of the water in the calorimeter is 22.150 °C.

↓

The mixture in the calorimeter is sparked and the olive oil completely reacted with oxygen → Temperature of the water in the calorimeter is 22.391 °C.

a. Calculate the calorimeter constant of the calorimeter in kJ K^{-1}.

(2 marks)

b. Calculate the energy released, in kJ, by the combustion of the olive oil in the calorimeter.

(1 mark)

c. Assuming that the olive oil is pure glyceryl trioleate, $C_{57}H_{104}O_6$, calculate the heat of combustion of olive oil, in kJ mol^{-1}.

(2 marks)

d. Write a balanced thermochemical equation for the combustion of glyceryl trioleate.

(3 marks)

e. If all the energy released by 1.00 g olive oil was transferred with 100 % efficiency to water, what mass of water would experience a temperature rise of 1.49°C?

(2 marks)

Total 10 marks

Question 5

At 460°C, the equilibrium reaction

$$SO_2(g) + NO_2(g) \rightleftharpoons NO(g) + SO_3(g)$$

has $K_c = 80.6$

A reaction flask, at 460°C, contains all four gases at the following concentrations:

$[SO_2] = 0.00250$ M, $[NO_2] = 0.00350$ M, $[NO] = 0.0250$ M, $[SO_3] = 0.0400$ M.

a. Calculate the pressure, in atm, in the reaction vessel when these concentrations were measured.

(3 marks)

b. i. Show that the reaction mixture is not at equilibrium and indicate the direction in which the reaction must shift to get to equilibrium.

(2 marks)

ii. How is it possible to tell, from pressure measurements, when the system has reached equilibrium?

(1 mark)

c. Subsequent testing shows that when equilibrium is established, all concentrations have changed, i.e. increased or decreased, by 0.00050 mol L^{-1}.
Calculate the pressure, in kPa, in the reaction vessel at equilibrium.

(1 mark)

d. The equilibrium between the weak acid carbonic acid and its conjugate base will resist changes in pH and is known as a buffer system. This equilibrium is described by the equation

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

This acts as a buffer system in blood.
Buffers are vital in almost all biological systems where a change in pH can affect the functioning of a cell. To prevent this happening, many pharmaceuticals, e.g. eye drops, are buffered. Buffered systems respond to change in such a way as to keep the pH constant.
The behaviour of a buffer system can be predicted or described by use of Le Chatelier's principle.

i. State Le Chatelier's principle.

(1 mark)

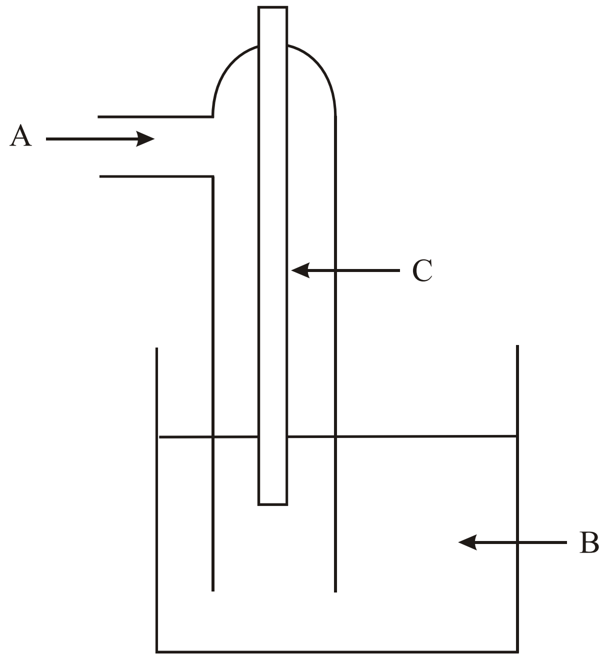
ii. How does Le Chatelier's principle suggest this buffer system will respond to an increase in pH of blood and why is this response consistent with relative reaction rates?

(2 marks)

Total 10 marks

Question 6

a. The diagram shown below represents a half-cell set up for use in a galvanic cell in which one of the components of the redox pair which constitute the half-cell is a gas.



i When this half-cell is connected to a Cu^{2+}(aq)/Cu(s) half-cell under standard conditions, the cell voltage as predicted from the electrochemical series would be 1.02 V.

Write the chemical formulae and states for the species, A, B and C, present in the half-cell.

A.___________

B.___________

C.___________

(3 marks)

ii. In terms of the solutions in the half-cells of a galvanic cell set up in a laboratory, explain why a salt bridge is essential to the operation of the cell and describe how and why it interacts with the half-cell containing the cathode in the half-cell identified in (i).

(3 marks)

iii. Why is silver nitrate, $AgNO_3$, not an appropriate salt to use in the salt bridge in a cell containing the Cl_2(g)/Cl^-(aq) half-cell?

(1 mark)

b. In an extended electrochemical series the following half-equations appear

$$O_3(g) + H_2O(l) + 2e^- \rightleftharpoons O_2(g) + 2OH^-(aq) \quad E^0 = +1.24 \text{ V}$$

$$In^{3+}(aq) + 3e \rightleftharpoons In(s) \quad E^0 = -0.34 \text{ V}$$

$$Y^{3+}(aq) + 3e^- \rightleftharpoons Y(s) \quad E^0 = -2.37 \text{ V}$$

i. In terms of definitions of reduction, what is unusual about the ozone, O_3, half-equation?

(1 mark)

ii. Write half-equations for the electrode reactions occurring during the electrolysis of a 1 M aqueous solution of yttrium(III) chloride, $YCl_3(aq)$.
(-) electrode

(+) electrode

(2 marks)

iii Electrolysis of 1 M aqueous solution of indium(III) nitrate using a consistent current of 2.51 A, produced 0.448 g of non-aqueous product at the (-) electrode. Given that 75 % of the electrical energy was converted to chemical energy, for how long, in minutes, did the electrolysis proceed?

(5 marks)

Total 15 marks

End of Section B

End of Trial Exam