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Engage Education Foundation

Units 3 and 4 Chemistry

Practice Exam Question and Answer Booklet

Duration: 15 minutes reading time, 2 hours 30 minutes writing time

Structure of book:

Section	Number of questions	Number of questions to be answered	Number of marks
A	30	30	30
B	15	15	100
		Total	130

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, rulers and a scientific calculator.
- Students are not permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied:

- This question and answer booklet of 31 pages.

Instructions:

- You must complete all questions of the examination.
- Write all your answers in the spaces provided in this booklet.

Section A – Multiple-choice questions

Instructions

Answer all questions by circling your choice.
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 marks will be given if more than one answer is completed for any question.

Questions

Use the following information to answer questions 1 and 2:

0.12 g of a metal was reacted with excess hydrochloric acid. 125 mL of hydrogen gas was collected at 27°C and 100 kPa.

Question 1

The amount of hydrogen gas, in mol, would be closest to:

A. 5.0
B. 0.52
C. 0.052
D. 0.0050

Question 2

The metal involved could be:

A. zinc
B. sodium
C. calcium
D. magnesium

Question 3

The amino acid, alanine, dissolves in water.

In an aqueous solution with a pH = 7, alanine is acting as:

A. an acid only.
B. a base only.
C. neither an acid nor a base.
D. both an acid and a base.

Question 4
Cellulose cannot be digested by humans because:

A. it is insoluble in water.
B. it contains no glucose.
C. it is not a carbohydrate.
D. the enzymes required to catalyse its hydrolysis are not present in humans.

Question 5
How many hydrogen atoms are there in a molecule of 3-nonanol?

A. 9
B. 19
C. 20
D. 21

Question 6
The number of structural isomers with the formula C_4H_9Cl is:

A. 1
B. 2
C. 3
D. 4

Question 7
If three glycine molecules (relative molecular mass 75) react together to form a tripeptide, the relative molecular mass of the product would be:

A. 171
B. 189
C. 207
D. 225

Question 8
This reaction between two or more amino acids to form a polypeptide is classified as:

A. condensation.
B. esterification.
C. hydrolysis.
D. nitrification.

Question 9
Consider the reaction:

$CH_3CH{=}CHCH_3 + Br_2 \rightarrow Z$

Z would likely represent:

A. $CH_3CHBrCHBrCH_3$
B. $CH_2BrCH_2CHBrCH_3$
C. $CH_3CHBrCH_2CH_2Br$
D. $CH_2BrCH_2CH_2CH_2Br$

Question 10
A sample of hydrocarbon contains 81.8% carbon by mass.

The empirical formula of the compound would be:

A. CH_4
B. CH_3
C. C_2H_5
D. C_3H_8

Question 11
Concentrated sulfuric acid reacts with glucose. One of the chemical reactions that can occur may be represented as:

$C_6H_{12}O_6(s) + 6H_2SO_4(l) \rightarrow 6C(s) + 6H_3O^+(aq) + 6HSO_4^-(aq)$

This reaction is best described as being:

A. dehydration only.
B. acid-base and redox only.
C. dehydration and acid-base only.
D. dehydration, acid-base and redox.

Question 12
An aqueous mixture of two substances (Y and Z) is subjected to analysis by both paper chromatography and high performance liquid chromatography (HPLC). In both forms of chromatography, component Z of the mixture was bonded more strongly to the stationary phase than component Y.

In terms of *R*f and *R*t, where *R*t is the retention time in HPLC, component Z has the:

A.	Higher Rf	Lower Rt
B.	Higher Rf	Higher Rt
C.	Lower Rf	Lower Rt
D.	Lower Rf	Higher Rt

Question 13
A 2.0 L sample of a gaseous hydrocarbon is burnt in excess oxygen. The only products of the reaction are 8.0 L of $CO_2(g)$ and 10.0 L of $H_2O(g)$, all at 100ºC and 1 atm pressure.

The formula of the hydrocarbon is:

A. CH
B. C_2H_4
C. C_4H_{10}
D. C_8H_{10}

Question 14
What mass of barium nitrate is required to produce 5.0g of barium sulphate in the presence of excess sodium sulphate?

A. 5.0g
B. 5.6g
C. 6.0g
D. 6.6g

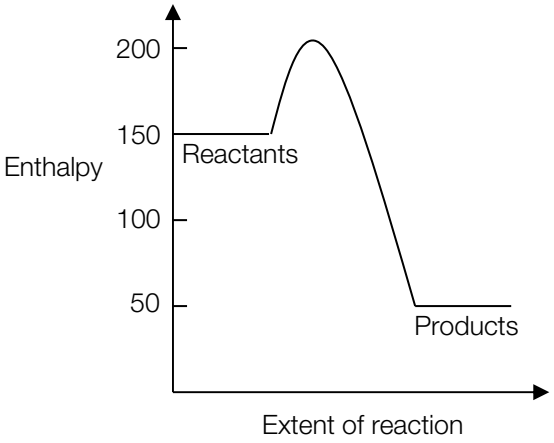
Question 15
How many double bonds exist in the straight-chain carboxylic acid, $C_{12}H_{18}O_2$?

A. 1
B. 2
C. 3
D. 4

Question 16
Magnesium chloride is to be generated by reacting 50 g of magnesium oxide powder with hydrochloric acid. Which of the following actions is **least likely** to lead to an increase in the rate of formation of magnesium chloride?

A. Grinding the magnesium oxide to a fine powder
B. Raising the temperature
C. Raising the atmospheric pressure
D. Raising the concentration of hydrochloric acid

Question 17
Consider the following energy profile diagram for a particular reaction.



The numerical value of the activation energy for the reverse reaction is

A. +150
B. +50
C. –150
D. –100

Question 18
In which one of the following would the position of the equilibrium **not** be affected by a volume change at constant temperature?

A. $2\ CO(g) + O_2(g) \rightleftarrows 2\ CO_2(g)$
B. $CaCO_3(s) + 2\ HCl(g) \rightleftarrows CaCl_2(g) + H_20(g) + CO_2(g)$
C. $N_2O_4(g) \rightleftarrows 2\ NO_2(g)$
D. $CO(g) + H_2O(g) \rightleftarrows H_2(g) + CO_2(g)$

Use the following information to answer questions 19 and 20:

Consider the equilibrium:

$2\ ClF_3(g) \rightleftarrows 3\ F_2(g) + Cl_2(g) \qquad \Delta H < 0$

Question 19

An expression for the equilibrium constant for this reaction is

A. $[ClF_3]^2/[F_2]^3[Cl_2]$
B. $3[F_2][Cl_2]/2[ClF_3]$
C. $[F_2]^3[Cl_2]/[ClF_3]^2$
D. $2[ClF_3]/3[F_2][Cl_2]$

Question 20

For the above equilibrium mixture, the temperature is lowered and as a result the amount, in mol, of ClF_3 changes by 0.010 mol.

The changes occurring would be:

	ClF_3	F_2	Cl_2
A.	Increase by 0.010 mol	Decrease by 0.015 mol	Decrease by 0.0050 mol
B.	Increase by 0.010 mol	Decrease by 0.0067 mol	Decrease by 0.020 mol
C.	Decrease by 0.010 mol	Increase by 0.015 mol	Increase by 0.0050 mol
D.	Decrease by 0.010 mol	Increase by 0.067 mol	Increase by 0.020 mol

Question 21

Potassium oxide is found in many fertilisers. It can be produced in two ways:

$K_2O_2 + 2\ K \rightleftarrows 2\ K_2O$ $K = 5.0 \times 10^{3}$

$2\ KNO_3 + 10\ K \rightleftarrows 6\ K_2O + N_2$, $K = 4.2 \times 10^{-4}$

The equilibrium constants for the following reactions respectively are:

$2\ K_2O_2 + 4\ K \rightleftarrows 4\ K_2O$,

$3\ K_2O + 0.5\ N_2 \rightleftarrows KNO_3 + 5\ K$

A. 10^4, 1.2×10^3
B. 10^4, 2.4×10^3
C. 2.5×10^7, 48.7
D. 5.0 x 103, 2.0×10^{-2}

Question 22

The energy released in a chemical reaction is directly converted to electrical energy in a/an:

A. Electrolytic cell
B. Hydrogen/oxygen fuel cell
C. Solar cell
D. Fossil-fuel power station

Question 23

In a gas-fired power station, the energy available from the chemical reaction is used to convert water in a boiler from liquid water to steam,

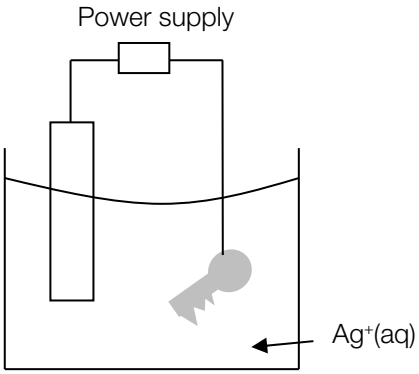
$H_2O(l) \rightleftarrows H_2O(g)\ \ \Delta H = +44.0\ kJ\ mol^{-1}$

The maximum mass of water, in grams, that could be converted from liquid water to steam by the complete combustion of two moles of ethane is

A. 1273.9
B. 35.4
C. 636.95
D. 70.77

Question 24

A student decided to silver-plate their locker key using the apparatus shown.



In this cell, the key is the:

A. Cathode and is connected to the positive terminal of the power supply
B. Cathode and is connected to the negative terminal of the power supply
C. Anode and is connected to the positive terminal of the power supply
D. Anode and is connected to the negative terminal of the power supply

Question 25

The combustion of heptane can be represented by the equation

$2C_7H_{16}(g) + 22O_2(g) \rightarrow 14CO_2(g) + 16H_2O(g) \qquad \Delta H = -9634 \text{ kJ mol}^{-1}$

The energy produced, in kJ, by the complete combustion of 45 kg of heptane is

A. 2.2×10^6
B. 2.2×10^3
C. 4.3×10^6
D. 4.3×10^3

Use the following information to answer questions 26 and 27:

In solution, OCl^- hydrolyses according to the equation:

$OCl^-(aq) + H_2O(l) \rightleftarrows HOCl(aq) + OH^-(aq)$

Question 26

100 mL of pure water at constant temperature is added to a 100 mL solution of 0.10 M NaOCl.

When the solution reaches equilibrium again, the:

A. $[H^+]$ has decreased
B. pH of the solution has decreased
C. Concentration of HOCl has increased
D. Value of the equilibrium constant has halved

Question 27

A fuel cell is set up based on the oxidation of methane. The equation for the anode half reaction is

$CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$

Assuming that all the energy of the oxidation reaction is converted to electricity, the amount of electric charge, in coulomb, obtained from the oxidation of two mole of methane is closest to:

A. 1.9×10^5
B. 9.7×10^4
C. 7.7×10^5
D. 1.5×10^6

Question 28

A table of redox couples and their standard reduction potentials is shown below:

Redox couple	E°
Ag^+/Ag	0.80 V
Cd^{2+}/Cd	–0.40 V
Pd^{2+}/Pd	0.92 V
Ni^{2+}/Ni	–0.24 V

Which of the following ranks the metals in decreasing order of their reductive activity?

A. Ni > Cd > Ag > Pd
B. Pd > Ag > Cd > Ni
C. Pd > Ag > Ni > Cd
D. Cd > Ni > Ag > Pd

Question 29

0.010 mol of chloral hydrate, $CCl_3CH(OH)_2$, is dissolved in a pure organic solvent. The resulting solution is made up to one litre exactly. In this solvent, the chloral hydrate dissociates to chloral, CCl_3CHO, and water. The chemical reaction for the process is:

$$CCl_3CH(OH)_2(\text{in solution}) \rightleftarrows CCl_3CHO(\text{in solution}) + H_2O(\text{in solution})$$

When the reaction has reached equilibrium the concentration of water in the solution is measured to be 0.0020 M.

The equilibrium constant for the reaction at this temperature would be

A. 0.20
B. 5.0×10^{-4}
C. 4.0×10^{-4}
D. 0.25

Question 30

A VCE chemistry student sets up a galvanic cell using two standard half cells with half reactions.

Half cell 1: $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$

Half cell 2: $Cr(s) \rightarrow Cr^{2+}(aq) + 2\ e^-$

Suitable materials for the electrodes of the two half cells are:

	Half cell 1	Half cell 2
A.	Platinum	Platinum
B.	Platinum	Chromium
C.	Chromium	Platinum
D.	Chromium	Chromium

Section B – Short-answer questions

Instructions

Answer all questions in the spaces provided.
In questions where more than one mark is available, appropriate working must be shown.
Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Questions

Question 1

a. Enzymes are an important part of our body as they perform many functions. Complete the table below by describing the components that make up the primary, secondary and tertiary structure of an enzyme.

	Brief Description
Primary	
Secondary	
Tertiary	

3 marks

b. A student carries out the following experiments on different enzymes:
In experiment A, the enzyme sample was heated from 25°C to 100°C.
In experiment B, the enzyme sample was added to a concentrated acid.
Choose **one** experiment and explain how it affects the structure of the enzyme.

2 marks

Total: 5 marks

Question 2

a. Maltose is a disaccharide formed from the reaction of two glucose molecules. Draw a molecule of maltose and label the ether linkage.

2 marks

b. When maltose is formed there is another product. Give the chemical formula for this product.

1 mark

c. A polysaccharide is made from the reaction of 9 glucose molecules. Calculate the mass of the polysaccharide if you have 0.120 mol of it.

3 marks

Total: 6 marks

Question 3

a. Fatty acids are a form of lipid. They have a carboxyl group attached to a long hydrocarbon chain. Using the polarity of fatty acids explain if a long fatty acid chain is likely to be soluble in water.

2 marks

b. Triglycerides are formed as a result of a condensation reaction between an alcohol and 3 fatty acid molecules. Name and draw this alcohol.

2 marks

Total: 4 marks

Question 4

a. Fill in the blanks:

In a high pH environment amino acids act as _____. They do so by _____

a hydrogen ion and developing an overall _____ charge.

2 marks

b. Generally, amino acids exist in a cationic, anionic or a dipolar form. What is the name given to an amino acid when it is in its dipolar form?

_____

1 mark

c. Glycine and alanine can react together to form two different compounds dipeptides. Draw these two dipeptides.

2 marks

Total: 5 marks

Question 5

While cleaning his house a chemist sees that an active ingredient in the cleaning liquid he is using is molecule X. He concludes that molecule X is an ester present in the detergent to give its signature orange smell.

a. Draw a reaction pathway for the production of molecule X with starting molecules octane and ethene, given that an intermediary step involves the production of ethanoic acid.

3 marks

b. Name molecule X.

_____

1 mark

Total: 4 marks

Question 6

a. A student wants to calculate the amount of common table salt in a piece of biscuit. In order to do so he decides to first remove all the water. He finds that the biscuit was 37% water. If the initial mass of the biscuit was 5.6g what is the final mass (after analysis)?

1 mark

b. The student then completely dissolves the biscuit in water. Which metal element should he isolate (separate out into a compound) in order to find the amount of salt?

1 mark

c. The student adds excess potassium nitrate to the solution in order to isolate the metal element from the rest of the biscuit. Is the student going to be successful in calculating the amount of salt in the biscuit? Explain with the aid of a chemical equation.

2 marks

d. Another student decides to carry out the same experiment, but instead of isolating a metal element to find the amount of salt, he decides to isolate a non-metal element. Name this element.

1 mark

e. After preparing a solution of the dried biscuit, the student adds excess lead (II) nitrate. Write an equation of the reaction that takes place.

1 mark

f. The student collects the precipitate and after weighing to constant mass he finds that the precipitate weighs 1.3g. What percentage of the biscuit is salt?

4 marks

g. The percentage of salt calculated is much higher than the percentage stated on the biscuit packet. Identify and explain one possible error that would account for this.

2 marks

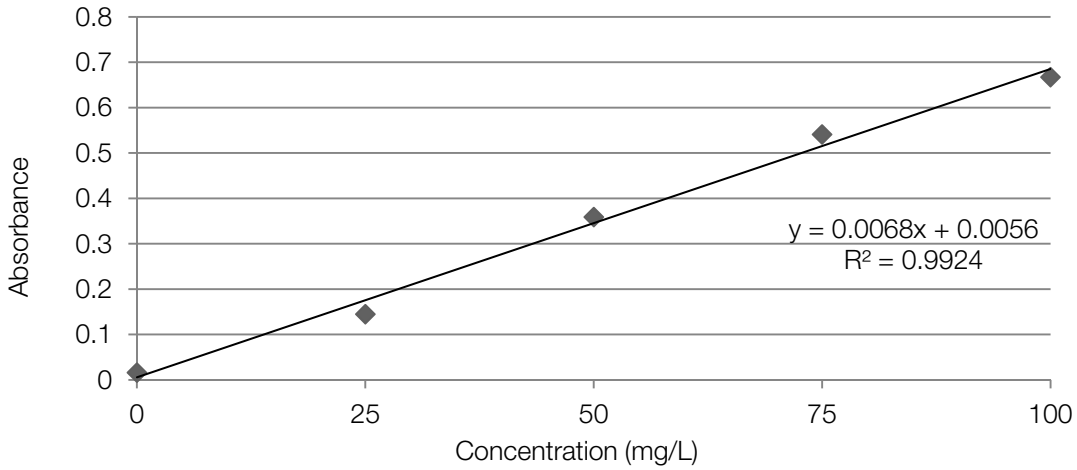
Total: 12 marks

Question 7

The fictional city of Milburn has a high rate of underground criminal activity. This activity came to an end when the Milburn Police Force discovered Fat Tony at the bottom of Port MacKillop Bay, weighed down by 'concrete boots' (that is, Fat Tony's feet were enclosed in a block of cement). It is well-known that there are two large concrete-producing factories with mob-connections in Milburn, and so the police contract a team of forensic chemists to compare the sample found with Fat Tony to samples from each of the concrete factories. The forensic chemists decided to use Atomic Absorption Spectroscopy (AAS) to quantitatively test for the presence of iron. The results from their experiment are as follows:

Iron concentration (mg/L)	Abs 1	Abs 2	Abs 3	Mean Absorbance
0	0.0167	0.0140	0.0165	0.0157
25	0.1473	0.1406	0.1461	0.1447
50	0.3569	0.3637	0.3554	0.3587
75	0.4949	0.5473	0.5800	0.5407
100	0.6729	0.6741	0.6549	0.6673

From these results, the chemists were able to plot a calibration curve, with absorbance on the Y axis and concentration on the X axis. The equation for the line of best fit was also calculated.



For each sample, between 0.35g and 0.45g of the concrete was crushed and dissolved in 100mL volumetric flasks. Triplicate measurements were taken for each sample:

Sample	Mass of sample (g)	Absorbance
Fat Tony's concrete – A	0.4171	0.2346
Fat Tony's concrete – B	0.4239	0.2870
Fat Tony's concrete – C	0.3831	0.2868
Concrete Factory 1 – A	0.3543	0.1933
Concrete Factory 1 – B	0.4249	0.2177
Concrete Factory 1 – C	0.4405	0.1895
Concrete Factory 2 – A	0.4521	0.2875
Concrete Factory 2 – B	0.4212	0.2672
Concrete Factory 2 – C	0.4282	0.2643

a. Complete the following table:

Sample	Mean mass of sample (g)	Mean Absorbance	Iron Concentration (mg/L)
Fat Tony's concrete			
Concrete Factory 1			
Concrete Factory 2			

2 marks

b. Identify which concrete factory was most likely involved with the death of Fat Tony.

1 mark

c. Calculate the percentage by mass, %(m,m), of iron in the sample of concrete taken from Concrete Factory 1.

2 marks

d. When the cement samples were run through AAS, a bright orange colour was emitted by the flame once the samples were exposed to the light from the iron cathode lamp used. Explain the origin of this bright orange colour, and why an iron cathode lamp was used as the light source.

3 marks

Total: 8 marks

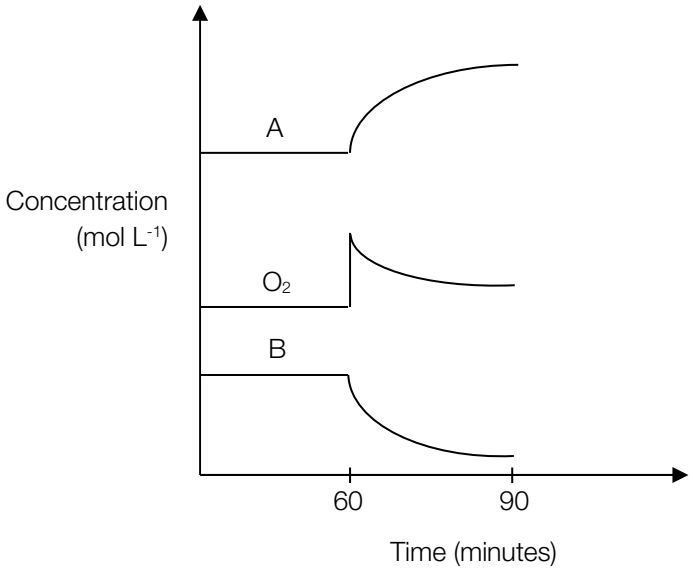
Question 8

Part of the Contact Process for the manufacture of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide, through the following reaction:

$2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g) \qquad \Delta H = -192\ kJ\ mol^{-1}$

A container was filled with an equilibrium mixture of sulfur dioxide, sulfur trioxide and oxygen in the presence of a catalyst. The container was initially at 450°C. The container had a fixed volume and was thermally well insulated.

Concentrations during an experiment are shown on the diagram below:



a. What change occurred at the 60 minute point?

1 mark

b. Which components of the equilibrium mixture are represented by A and B?

A:

B:

1 mark

c. Give explanations for the changes in concentration that occur in A, B and O_2 between 60 and 90 minutes.

3 marks

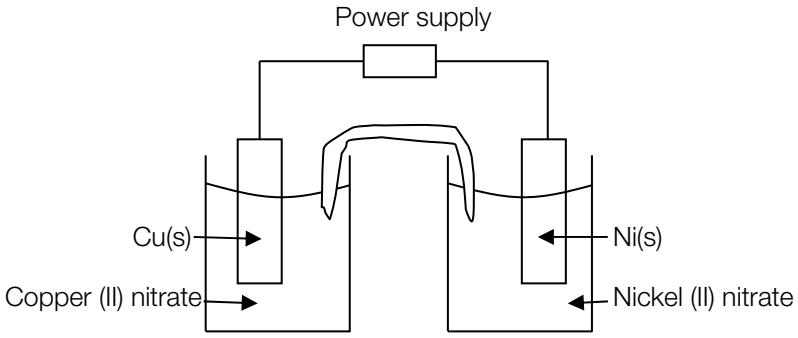
d. Would the temperature of the mixture increase, decrease or remain the same between 60 and 90 minutes? Explain your answer.

2 marks

Total: 7 marks

Question 9

A galvanic cell was constructed as shown in the diagram.



The conditions of the galvanic cell were as described below:

Initial mass of nickel electrode: 8.34g

Initial mass of copper electrode: 2.70g

Initial nickel (II) nitrate solution: 100.0mL at 0.100M

Initial copper nitrate solution: 100.0mL at 0.100M

Salt bridge concentration: 0.050M

a. Calculate the standard cell potential. In your answer, include the overall equation for the cell reaction.

2 marks

After a period of time, a solid deposit that had formed on the copper electrode was removed and dried. The deposit had a mass of 0.395 g.

b. Calculate the final mass of the nickel electrode.

3 marks

c. Calculate the final concentration of the nickel(II) nitrate solution.

2 marks

Total: 7 marks

Question 10

The following equations outline the sequence of steps in the Ostwald process for the manufacture of nitric acid.

Step 1: $4\ NH_3(g) + 5\ O_2(g) \rightleftarrows 4\ NO(g) + 6\ H_2O$ $\Delta H = -950\ kJ\ mol^{-1}$ (carried out at 900°C)

Step 2: $2\ NO(g) + O_2(g) \rightleftarrows 2\ NO_2(g)$ $\Delta H = -114\ kJ\ mol^{-1}$

Step 3: $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$ $\Delta H = -117\ kJ\ mol^{-1}$

a. State Le Chatelier's principle.

2 marks

b. Using your answer above explain the likely reaction conditions required at each step of the Ostwald process to maximise the yield and production rate of nitric acid..

Step 1:

Step 2:

Step 3:

6 marks

Total: 8 marks

Question 11

A 0.05 mol L^{-1} solution of sodium chloride was electrolysed using graphite electrodes. Separate pieces of litmus paper were dipped into the solution directly next to each electrode.

The following observations were made:

Polarity of electrode	Observation	Colour of litmus paper
Positive	Bubbles	Red
Negative	Bubbles	Blue

a. Draw and label a diagram to represent this cell.

2 marks

b. Account for the observations and colour of litmus paper at the anode and cathode. Include relevant chemical equations in your answer.

4 marks

c. What is the difference between the electrolytic cell described above and a galvanic cell, in terms of energy requirements and conversions?

2 marks

Total: 8 marks

Question 12

On silver cutlery, compounds of silver can build up on the surface to produce tarnish. One way to remove this tarnish is to place the cutlery into an aluminium tray filled with warm sodium hydrogen carbonate solution and leaving it overnight.

a. Explain, with the use of equations, the chemistry involved in the aluminium tray method.

4 marks

b. Identify an advantage of the aluminium tray method.

1 mark

Total: 5 marks

Question 13

Boric acid (H_3BO_3) is a weak acid. Its conjugate base, the borate ion, exists in water as $B(OH)_4^-$.

A solution of pure sodium borate, $NaB(OH)_4$, is prepared in water at 25°C. The borate ion dissociates according to the equation:

$B(OH)_4^-(aq) \rightleftarrows OH^-(aq) + H_3BO_3(aq)$

a. Give an expression for the equilibrium constant for the reaction above.

1 mark

At equilibrium in a particular solution of $NaB(OH)_4$, the concentration of $B(OH)_4^-$ is exactly 0.100 M and the pH is 11.11.

b. Calculate the hydrogen ion and hydroxide ion concentrations in the solution.

2 marks

c. Hence give the H_3BO_3 concentration in the solution.

1 marks

The equilibrium constant for the dissociation of boric acid is given by

$$K_a = [H^+][B(OH)_4^-]/[H_3BO_3]$$

d. Use the data from part b and c to calculate the value of the K_a of boric acid.

1 mark

Total: 5 marks

Question 14

A group of chemistry students go camping for 8 weeks and decide to use liquid ethanol (CH_3CH_2OH) to satisfy their energy needs. They plan to use two different methods of generating energy from the ethanol.

Some of the ethanol is to be directly burnt for heating and cooking

a. Write a thermochemical equation for the complete combustion of ethanol.

2 marks

The average energy need for heating and cooking over the 8-week period is 200 MJ per week.

b. Calculate the total mass of ethanol needed to satisfy the heating and cooking requirements of the students (remembering that 1 MJ = 10^3kJ).

3 marks

Some ethanol may also be used for electric power for lighting, refrigeration, computing and other electronic equipment. This can be provided by a fuel cell with an acidic electrolyte.

The cell reaction is identical to the complete combustion of ethanol.

The voltage across the fuel cell is 1.15 V.

c. Give the half reactions occurring at the anode and the cathode.

2 marks

d. Calculate the electrical energy provided per mole of ethanol consumed in the fuel cell.

2 marks

An alternative way of generating electricity from ethanol is to use it as the fuel for an internal combustion engine driving a generator.

e. Suggest one reason why the fuel cell would be better than the generator for this purpose.

1 mark

Total: 10 marks

Question 15

The Down's cell is used for the industrial preparation of sodium and chlorine from molten sodium chloride.

a. Write the equations of the reactions that occur at the anode and cathode.

2 marks

b. An iron mesh screen is a necessary part of the Down's cell. What is its primary role?

1 mark

A particular Down's cell operates for 1.00×10^4 seconds at a current of 96.5 A.

c. Calculate the volume of chlorine produced at STP.

3 marks

Total: 6 marks

End of Booklet

Looking for solutions? Visit www.engageeducation.org.au/practice-exams