Engage Education Foundation

Units 3 and 4 Chemistry

Practice Exam Question and Answer Booklet

Duration: 15 minutes reading time, 2 hours writing time

Structure of book:

Section	Number of questions	Number of questions to be answered	Number of marks
A	30	30	30
B	10	10	90
		Total	120

- 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 24 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

Question 1

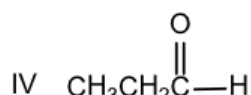An element X has ions XO_2^- and XO_3^-. Which of the following is element X?
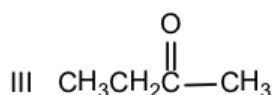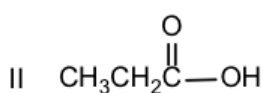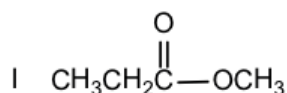
    A.   Chromium
    B.   Sulfur
    C.   Phosphorus
    D.   Carbon

Question 2

Which of the following molecules is able to form a polymer?

    A. C_2H_4
    B. C_3H_8
    C. $C_4H_{10}O$
    D. $C_4H_7O_2$

Question 3

I $CH_3CH_2C(=O)-OCH_3$ II $CH_3CH_2C(=O)-OH$

III $CH_3CH_2C(=O)-CH_3$ IV $CH_3CH_2C(=O)-H$

Which of the following rows identifies the compounds correctly?

	I	II	III	IV
A	Ester	Aldehyde	Ketone	Carboxylic acid
B	Ketone	Carboxylic acid	Ester	Aldehyde
C	Ester	Carboxylic acid	Ketone	Aldehyde
D	Carboxylic acid	Ester	Aldehyde	Ketone

Question 4

Which of the following equations represents aerobic respiration?

    A. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
    B. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
    C. $C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$
    D. $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

Question 5

A 0.05M sample of each of the following substances are dissolved completely in 100mL of water. Which solution would contain the largest number of ions?

    A.   HCl

    B. $(NH_4)_2CO_3$

    C. Na_3PO_4

    D. $Ca(OH)_2$

Use the following equation for questions 6 and 7:

$$HS^-(aq) + CO_3^{2-}(aq) \leftrightharpoons S^{2-}(aq) + HCO_3^-(aq)$$
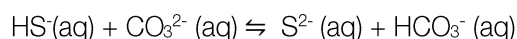
Question 6

The equation describes:

    A.   A redox and acid-base reaction

    B.   A redox reaction only

    C.   An acid base reaction only

    D.   A decomposition reaction

Question 7

Which of the following is a true statement about the equation?

    A. $HS^-(aq)$ is acting an oxidant

    B. $HS^-(aq)$ is acting a base

    C. HCO_3^- is acting as a reductant

    D. HCO_3^- is acting as an acid

Question 8

A chemist is given 4 samples of solution to analyse. The samples are known to contain ions of potassium, silver, barium and calcium. To determine which sample contains which ions he tests half of each sample with chloride ions and the second half with sulfate ions.

The results are as follows

Sample	1	2	3	4
Chloride	No precipitate	No precipitate	No precipitate	Precipitate
Sulfate	Precipitate	Some precipitate	No precipitate	Some precipitate

Which row of the following table shows the contents of each sample?

	1	2	3	4
A.	Ag^+	Ba^{2+}	Ca^{2+}	K^+
B.	K^+	Ag^+	Ba^{2+}	Ca^{2+}
C.	Ba^{2+}	Ca^{2+}	K^+	Ag^+
D.	Ca^{2+}	Ag^+	Ba^{2+}	K^+

Question 9

Esters can be hydrolysed in the presence of an enzyme called esterase. What effect does the presence of esterase have on the hydrolysis process?

    A. the rate of forward reaction increases more than the rate of reverse reaction
    B. the position of equilibrium shifts to the right
    C. the rate of forward and reverse reaction remain unchanged
    D. the rate of forward and reverse reaction increase equally

Question 10

In which of the following compounds is rhenium in the highest oxidation state?

    A. Re_2O_3
    B. $ReCl_5$
    C. $NaReO_4$
    D. $ReClO$

Question 11

What makes up the inner circuit of a galvanic cell?

    A. The flow of electrons from anode to cathode
    B. The flow of ions in the salt bridge
    C. The flow of electrons in the salt bridge
    D. The flow of ions from anode to cathode

Question 12

The pH of 0.01 mol L^{-1} solutions of nitrous, lactic and hydrochloric acids was measured. Which solution would have the highest pH?

    A. hydrochloric
    B. lactic
    C. nitrous
    D. The pH of all three would be the same

Question 13

Which of the following properties is true for a gaseous system in equilibrium?

    (i) the concentrations of reactants is equal to the concentrations of products
    (ii) the pressure of the system is constant
    (iii) the concentration of all species is constant
    (iv) the rate of forward reaction is equal to the rate of reverse reaction

    A. (i) (ii) and (iii)
    B. (i) (ii) and (iv)
    C. (ii), (iii) and (iv)
    D. (iv) only

Use the following equation for questions 14 and 15:

$$Br_2 + 2Fe^{2+} \rightarrow 2Br^- + 2Fe^{3+}$$
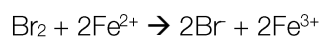
Question 14
What is the reducing agent in the reaction?

    A. Br_2
    B. Fe^{2+}
    C. Fe^{3+}
    D. Br^-

Question 15
What voltage is the reaction likely to produce?

    A. 1.09V
    B. 0.77V
    C. 0.33V
    D. 0.30V

Question 16
An unknown salt is dissolved in a 300.00mL beaker of water. The beaker becomes cold to touch almost instantly. Which one of the following is the best explanation for this observation?

    A. The reaction is exothermic with a low activation energy
    B. The reaction is exothermic with a high activation energy
    C. The reaction is endothermic with a low activation energy
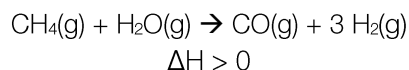   D. The reaction is endothermic with a high activation energy

Question 17
How many electrons are exchanged in the process of converting H_3PO_2 to phosphoric acid?

    A. 2
    B. 3
    C. 4
    D. 5

Question 18
Hydrogen can be produced via the following reaction:

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3\ H_2(g)$$
$$\Delta H > 0$$
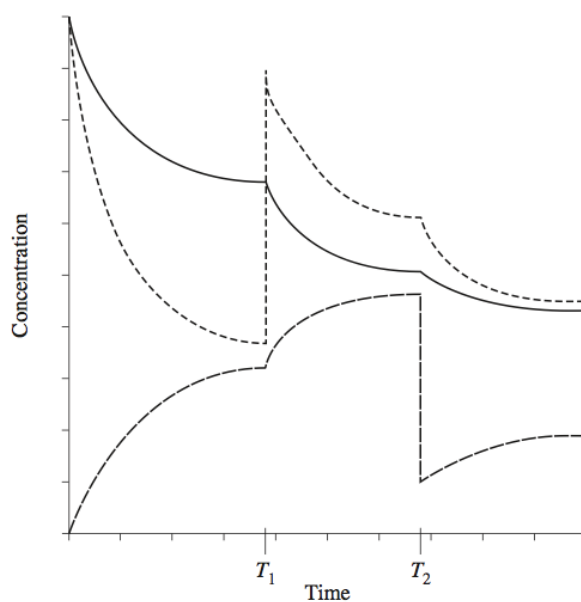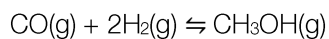
Which of the following changes to the system will increase the yield of carbon monoxide?

    A. increasing total pressure
    B. decreasing the partial pressure of water vapour
    C. removing hydrogen gas as it is produced
    D. decreasing the temperature of the system

Question 19
The graph shows the concentrations over time for the system:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Which of the following options shows the changes that took place at T_1 and T_2?

	T_1	T_2
A	CO added	CO and H_2 removed
B	H_2 added	CO removed
C	CO added	CH_3OH removed
D	H_2 added	CH_3OH removed

Question 20
How many moles of oxygen will be consumed in the complete combustion of the compound below if 2804.2 kJ of energy is released?
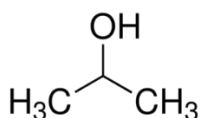
   A. 9 mol
   B. 6.3 mol
   C. 1.4 mol
   D. 4.5 mol

Question 21
What mass of water is produced through the combustion of ethane if 2335.5kJ of energy is released?

   A. 1.5g
   B. 4.5g
   C. 81g
   D. 162g

Question 22
What mass of anhydrous sodium carbonate is required to neutralize 50.00mL of 1M acetic acid?

    A. 2.65g
    B. 0.0265g
    C. 4.5g
    D. 106g

Question 23
Identify the oxidant in the following reaction:

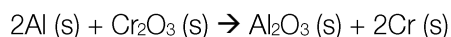$$2Al\ (s) + Cr_2O_3\ (s) \rightarrow Al_2O_3\ (s) + 2Cr\ (s)$$

    A. Al
    B. Cr_2O_3
    C. Al_2O_3
    D. Cr

Question 24
A student is trying to find an appropriate solution for a salt bridge. Which two solutions should he mix to produce an appropriate salt bridge solution?

    I. Na^+
    II. Cl^-
    III. Ag^+
    IV. NO_3^-

    A. I and III
    B. II and II
    C. I and IV
    D. II and IV

Question 25
Which of following processes is used to produce ethanol from ethylene?

    A. Addition polymerization
    B. Esterification
    C. Halogenation
    D. Hydration

Question 26
Which of the following reactions is a substitution reaction?

    A. $CH_3CH_2CH_2CH_2Br + Br_2 \rightarrow CH_3CH_2CH_2CHBr_2 + HBr$
    B. $CH_3CH_2CHCH_2 + Br_2 \rightarrow CH_3CH_2CHBrCH_2Br$
    C. $CH_3CH_2CH_2COOH + CH_3OH \rightarrow CH_3CH_2CH_2COOCH_3 + H_2O$
    D. $CH_3CH_2CHCH_2 + H_2 \rightarrow CH_3CH_2CH_2CH_3$

Question 27

A student carries out a gravimetric analysis to determine the content of sulfur in a certain brand of fertilizer. The answer obtained by the student is much smaller than the percentage composition listed on the back of the fertilizer packet. Which of the following can be a possible explanation for the discrepancy?

    A. The precipitate was not dried to constant mass
    B. The precipitate was not properly washed
    C. Some of the precipitate was filtered out
    D. The oven was not hot enough

Question 28

Which one of the following statements is true for both galvanic cells and electrolytic cells?

    A. a. Anions migrate to the cathode in both cells.
    B. b. The anode is positive in both
    C. c. Reduction occurs at the negative electrode in both cells.
    D. d. Reduction occurs at the cathode in both cells.

Question 29

$$\square\square = \frac{[\square]^4[\square][\square]}{\square^2\square^2}$$

Which of the following is the corresponding equation for the above $\square\square$?

    A. $A^2B^2 \rightarrow E^4DC$
    B. $2A + 2B \rightarrow C + D + 4E$
    C. $C + D + 4E \rightarrow 2A + 2B$
    D. $A + B \rightarrow C + D + E$

Question 30

Which of the following techniques is best suited for the detection of lead in drinking water?

    A. gravimetric analysis
    B. atomic absorption spectroscopy
    C. thin layer chromatography
    D. mass spectroscopy

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. TLC, HPLC and GC separate compounds using the same basic principle. What is this principle?

_____

_____

_____

2 marks

b. Why are the particles of the stationary phase in HPLC significantly smaller than those compared to traditional column chromatography?

_____

_____

_____

2 marks

c. Why is high pressure necessary in HPLC?

_____

_____

_____

1 mark

d.   Define the following terms:
      i. Adsorption

      _____

      _____

      _____

      ii. Desorption

      _____

      _____

      _____

      iii. Eluent

      _____

      _____

      _____

                                                                3 marks
                                                        Total: 8 marks

Question 2

A 100.00mL solution of lead ions was reacted with excess chloride ions.

a.   Write an equation for the reaction including states.

_____

_____

2 marks

b.   After washing and drying the precipitate it weighed 0.607g. What was the original concentration of the lead solution?

_____

_____

_____

_____

3 marks

c.   The mass of dried precipitate was supposed to be 0.600g. Give two reasons for the discrepancy.

_____

_____

_____

2 marks

Total: 7 marks

Question 3
A student wishes to identify an unknown hydrocarbon using a 100mL bomb calorimeter. Before carrying out the experiment he calibrates the calorimeter by burning 3.00g of ethane. The temperature of the water in the calorimeter rises by 2.45°C.

a.   What is the calibration factor?

_____

_____

_____

                                                                                  2 marks

The student then burns 3.00mL of the unknown hydrocarbon. His teacher tells him the hydrocarbon has a density of 0.980g/mL.

b.   Calculate the mass of the unknown hydrocarbon that is burnt.

_____

_____

_____

                                                                                   1 mark

c.   When the unknown hydrocarbon is burnt the temperature of the calorimeter rises by 2.237°C. What amount of energy is released?

_____

_____

_____

                                                                                   1 mark

d.   The hydrocarbon is known to have a molar mass of 86g/mol. Identify the hydrocarbon showing all working out.

_____

_____

_____

_____

_____

3 marks

e.   Another student carried out the exact same experiment with a calorimeter with the same calibration factor but he found the unknown hydrocarbon to be pentane. Identify and explain a possible reason the second student got a different answer.

_____

_____

_____

_____

_____

2 marks

Total: 9 marks

Question 4

a. Name the amino acids that make up the above tripeptide.

_____

_____

_____

1 mark

b. Circle the peptide linkages on the diagram above.

1 mark

c. If the tri-peptide is added to a 0.1M H_2SO_4 solution & boiled, the bonds between the amino acids are broken and the individual amino acids are produced.
    i. What name is given to this type of reaction?

_____

1 mark

    ii. Write the semi structural formula of each of the amino acids produced at the pH of the solution.

_____

_____

_____

_____

_____

_____

4 marks

d. If the amino acids were joint together to make another tri peptide what type of reaction would they undergo?

_____

_____

1 mark

Another peptide, peptide X, known to contain a combination of 5 different amino acids is analysed in a classroom using paper chromatography.

15cm ●	alanine
10cm ●	glycine
●	methionine
5cm ●	serine
2cm	
●	glutamine
1cm	
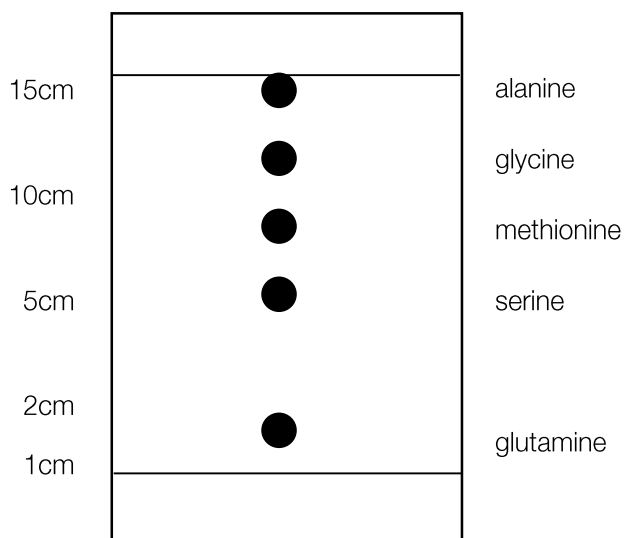
e. Calculate the Rf of any two amino acids.

_____

_____

_____

_____

_____

2 marks

f.   If the solvent front only reached 12cm, how far would methionine and serine have travelled from the starting point of 1cm?

_____

_____

_____

_____

_____

                                                                          4 marks

A student wished to analyse the structure of peptide X, and therefore wanted to know its primary structure.

g.   What is meant by a protein's primary structure?

_____

_____

                                                                           1 mark

h.   What information does the TLC result provide in analysing the primary structure of the protein?

_____

_____

_____

_____

                                                                          2 marks
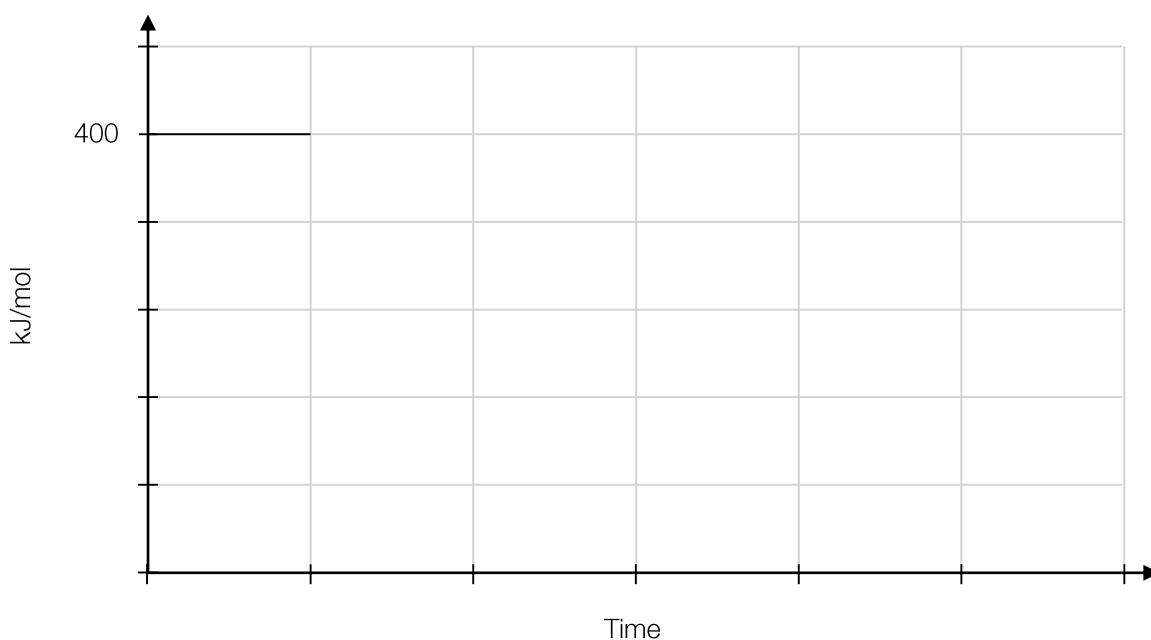   Total: 17 marks

Question 5

The decomposition of one mole of ethanal, CH_3CHO, releases 20kJ of energy and produces methane and carbon monoxide.

a. Write a thermochemical equation for the decomposition of ethanal.

_____

_____

_____

2 marks

b. If the activation energy of the reverse reaction is 330kJ/mol and the initial energy of enthanal is zero, complete the reaction profile below.

3 marks

c. On the graph above, show the reaction profile for the same reaction is the presence of a catalyst.

1 mark

d. On the graph above, show the reaction profile for the same reaction with double the amount of reactant and products.

1 mark

Total: 7 marks

Question 6

A chemist wishes to determine the percentage purity of a barium chloride sample. He expects the purity to be 85%. He plans to carry out the experiment by dissolving the barium chloride in 250.00mL of de-ionised water in a volumetric flask and then take a 20.00mL sample for analysis and add phosphate ions to make barium phosphate.

a.   Write a balanced ionic equation with states for this reaction.

_____

_____

_____

2 marks

b.   With the equipment that he has the chemist can collect a maximum of 1.2g of barium phosphate. What is the maximum mass of the sample he should dissolve in the volumetric flask to collect the maximum amount of precipitate?

_____

_____

_____

_____

_____

_____

_____

4 marks

Total: 6 marks

Question 7

The following chemical reaction represents the ionization of ethanoic acid in water:

$$CH_3COOH(l) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$
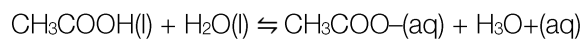
a.   Why is a double headed arrow used?

_____

_____

_____

1 mark

b.   Calculate the pH of 100 mL of 0.500 M CH_3COOH solution.

_____

_____

_____

_____

_____

3 marks

c.   Write the equation for the ionization of hypochlorus acid in 100ml of water.

_____

_____

_____

2 marks

d.   Given that the 3.0mg of hypochlorus acid was used, what is the pH of the solution?

_____

_____

_____

_____

_____

_____

_____

_____

4 marks

Total: 10 marks

Question 8

A company that makes table salt is required by law to include the percentage sodium in its product on the packaging of its product. The laboratory is given a 100g packet to table salt for analysis.
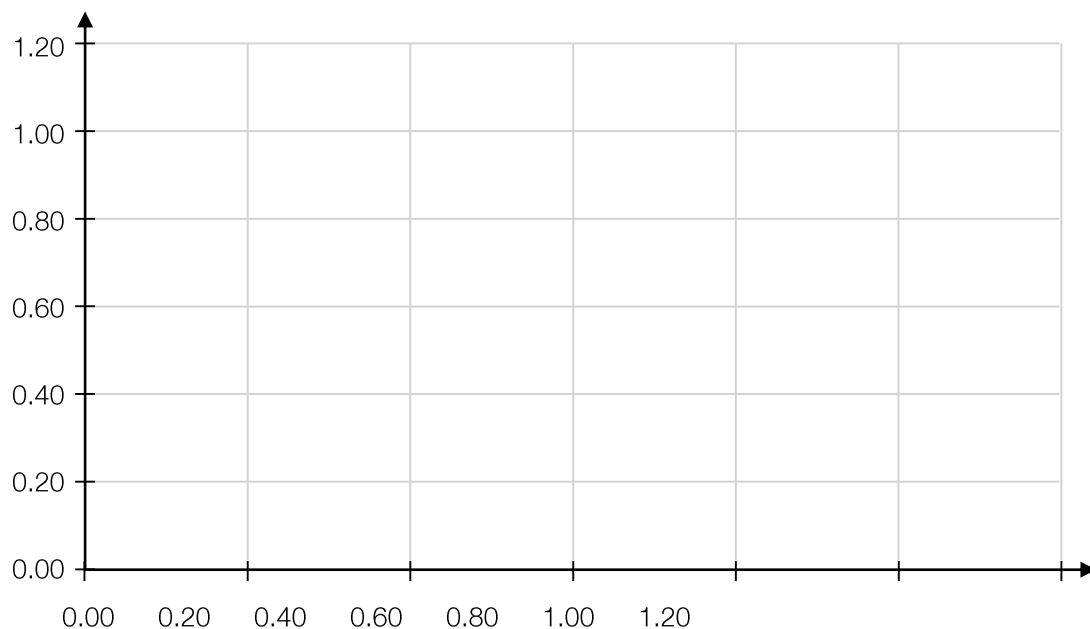
a. Before carrying out the test using atomic absorption spectroscopy the chemist calibrates the machine. Identify 2 features of the solution used for calibration.

_____

_____

_____

<div align="right">2 marks</div>

These are the results of the calibration:

Concentration (ppm)	Absorbance
0	0.004
0.1	0.156
0.2	0.326
0.4	0.594
0.6	0.928

b. Plot these results on the graph below.

<div align="right">2 marks</div>

The chemist dissolves 5 grams of table salt in a 250mL flask. He then takes a 10mL sample for analysis. The absorbance measures at 0.804.
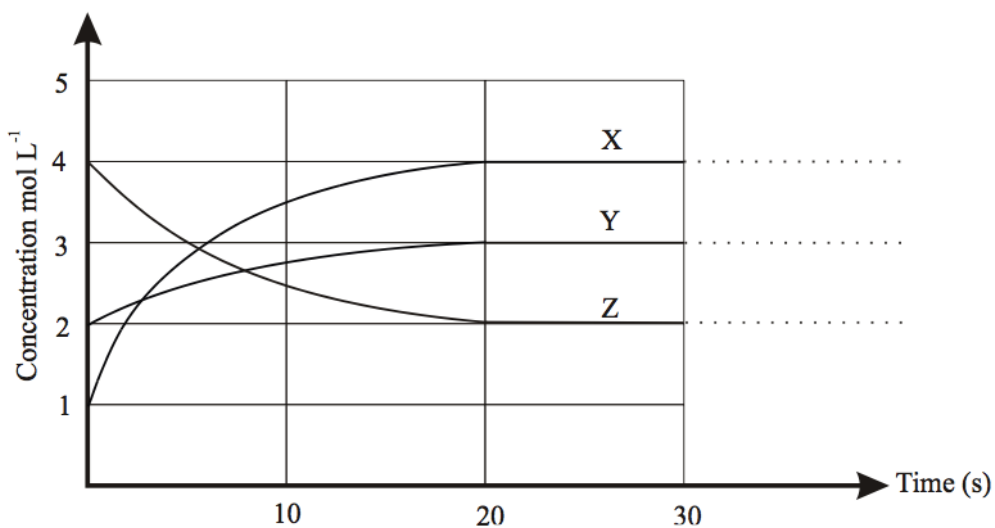
c.   What is the percentage composition of sodium in the packet of salt?

_____

_____

_____

_____

_____

_____

_____

4 marks

Total: 9 marks

Question 9

The graph below shows a 500mL gaseous system reaching equilibrium.

a.   At what time does the system reach equilibrium?

_____

1 mark

b.   Complete the table:

	Initial		Equilibrium	
	Concentration	Amount	Concentration	Amount
X				
Y				
Z				

4 marks

c.   Write the equation of the reaction and calculate the value of the equilibrium constant.

_____

_____

_____

_____

_____

4 marks

d.   At 30s the volume of the container is halved. On the graph on the previous page show the changes that would occur.
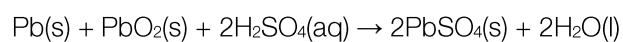
3 marks

Total: 12 marks

Question 10
A car battery is a lead acid battery made of 6 galvanic cells. Jane accidently leaves her car light on all night. When she returns in the morning her car doesn't start because the battery has died.

a.   Explain why the battery is dead.

_____

_____

_____

2 marks

The discharge reaction for a lead acid battery is:

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

b.   Write the reactions at the anode and cathode when the battery is recharging.

   Anode:

_____

   Cathode:

_____

_____

4 marks

Total: 6 marks

End of Booklet

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