Student Number	
Mark / 43	

Chemistry Assessment

Task 2 Term 1 2009

Theory

Acidic Environment
& Chemical Monitoring

Answers

General Instructions

- **Reading time** – 5 minutes
- **Working time** – 50 minutes
- **Write using black or blue pen**
- **Write your Student Number at the top of this page**
- **Board-approved calculators may be used**

A data sheet and a periodic table are provided at the back of the paper.

Total Marks – 43

Part A – 10 marks

- Attempt Questions 1-10
- Allow about 10 minutes for this part

Part B – 33 marks

- Attempt Questions 11-19
- Allow about 40 minutes for this part

Part A: Multiple Choice: 10 marks
Attempt Questions 1-10
Allow about 10 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

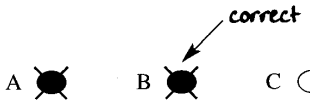
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



▸ Mark your answers for the multiple choice questions in the multiple choice grid on page -----

Multiple Choice

1. Which of the following reactions represents the Haber process?

(A) $O_2(g) + O(g) \rightleftharpoons O_3(g)$

(B) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(C) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(D) $CO_2(g) + H_2O(g) \rightleftharpoons H_2CO_3(g)$

Outcomes : H8, H10

2. Consider the following reaction at equilibrium.

$2NO_2(g) \rightleftharpoons N_2O_4(g) + \text{heat}$

What would be the effect of a decrease in pressure on this system?

(A) Heat will be absorbed.

(B) The equilibrium will not be disturbed.

(C) The concentration of N_2O_4 will increase.

(D) The rate of reverse reaction will decrease.

Outcomes : H8, H10

3. Which of the following represents a dilute solution of a strong acid?

(A) 0.1 M CH_3COOH

(B) 0.1 M H_2SO_4

(C) 2.0 M CH_3COOH

(D) 2.0 M H_2SO_4

Outcomes : H8, H10

4. Which of the following is a common industrial source of nitrogen oxides in air?

(A) smelting metal ores

(B) lightning strikes in air

(C) volcanoes

(D) combustion of fuels in internal combustion engines

5. Identify the substance which is frequently used in foods as preservative.

(A) sulfuric acid

(B) hydrochloric acid

(C) acetic acid

(D) nitric acid

Outcomes : H4, H8

6. 16.0 g of a gas , X , occupies 6.20 L at 25^0C and 100 kPa. Identify gas X.

(A) N_2O_4

(B) NO_2

(C) CO_2

(D) SO_2

Outcomes : H10

7. What is the common name of 2-hydroxypropane - 1,2,3 - tricarboxylic acid?

(A) citric acid
(B) acetic acid
(C) oxalic aci
(D) butanoic acid

Outcomes : H9

8. Which of the following best describes the combustion of butane in limited oxygen?

(A) $C_4H_{10} + 13/2\ O_2 \rightarrow 4CO_2 + 5H_2O$
(B) $\mathbf{C_4H_{10} + 9/2\ O_2 \rightarrow C + 2CO + CO_2 + 5H_2O}$
(C) $C_3H_8 + 5\ O_2 \rightarrow 3CO_2 + 4H_2O$
(D) $C_3H_8 + 7/2\ O_2 \rightarrow C + CO + CO_2 + 4H_2O$

Outcomes : H9, H10

9. The chemical equation describing the reaction between hydrofluoric acid and potassium hydroxide is shown.

$$HF\ (aq) + KOH\ (aq) \rightleftharpoons H_2O\ (l) + KF\ (aq)$$

Which option represents a conjugate acid/base pair for this reaction?

	Acid	*Conjugate base*
(A)	**HF**	**F^-**
(B)	KOH	K^+
(C)	H_2O	KOH
(D)	H^+	H_2O

10. Which chemical is the most appropriate to use when minimising damage due to acid or base spills in a chemical laboratory?

(A) sodium hydroxide

(B) sodium nitrate

(C) sodium hydrogen carbonate

(D) cloudy ammonia

Part A . Answer grid for multiple choice questions **Total .....**

1.	A O	B ●	C O	D O
2.	A ●	B O	C O	D O
3.	A O	B ●	C O	D O
4.	A O	B O	C O	D ●
5.	A O	B O	C ●	D O
6.	A O	B O	C O	D ●
7.	A ●	B O	C O	D O
8.	A O	B ●	C O	D O
9.	A ●	B O	C O	D O
10	A O	B O	C ●	D O

Part B Free Response Questions

Attempt Questions 11- 19
Allow about 40 minutes for this part

▸ ***Show all relevant working in questions involving calculations.***

Question 11 (6 marks)

Explain the choice of temperature and pressure conditions and catalyst used to optimize the yield in the Haber process.

Sample answer

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + heat$$

Temperature*: The forward reaction is exothermic so the increase in temperature will inhibit the production of NH_3. However, low temperatures lead to a very slow reaction. A compromise temperature of 450^0C is used to achieve a moderate yield at a faster rate.*

Pressure*: An increase in pressure will favour the reaction that exerts less pressure (Le Chatelier) ie the forward reaction (gas ratios 4:2)The reaction is carried out under high pressure to favour the production of NH_3*

Catalyst*: Fe_3O_4 catalyst is used to increase the reaction rate so that equilibrium is achieved more quickly at a moderate compromise temperature.*

Marking criteria	Marks
• Gives clear explanation of all three conditions of temperature, pressure and catalyst	6
• Explains two conditions, identifies the third	5
• Explains two conditions	4
• Identifies three conditions or • Explains one condition, identifies another	3
• Identifies two conditions or • explains one condition	2
• Identifies one condition of temperature or pressure or the catalyst	1

Outcomes H4, H8, H10

Question 12 (6 marks)

Consider the following information concerning acids.

0.01 mol L^{-1} solution	*pH*
Acetic acid	3.3
Hydrochloric acid	2.0

(a) Explain the difference in pH between the two acids.
Use equations to demonstrate your answer. (4 marks)

Sample Answer

Hydrochloric acid is a strong acid that completely ionizes in water. The concentration of H^+ is high and the pH is low.

$HCl + H_2O \rightarrow Cl^- + H_3O^+$

Acetic acid is a weak acid that only partially ionizes in water. There are less H^+ and so the pH is higher than HCl.

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

Marking criteria	**Marks**
• Explains the difference in pH with relevant equations	4
• Explains the pH difference with one correct equation	3
• Explains the pH difference with no equations	2
• Gives one equation or • Explains the pH of one acid	1

Outcomes : H8

(b) 0.01 M HCl has a pH of 2.0. What volume of water must be added to 50.0 mL of this solution to obtain a final pH of 3.0? (2 marks)

Sample Answer

if pH = 3, then $[H^+] = 0.001\ molL^{-1}$

$c1v1 = c2v2$

$0.01 \times 0.05 = 0.001 \times v2$

$v2 = 0.50L$

volume of water that needs to be added = 0.5L - 0.05 L

$= \mathbf{0.45\ L}$

Marking criteria	Marks
• Correctly calculates volume to be added with relevant working	2
• Calculates new $[H^+]$ or • Calculates v2	1

Outcomes : H10

Question 13 (3 marks)

Sulfur dioxide is a gas that can contribute to acid rain.

(a) Give an equation to show the formation of acid rain with sulfur dioxide. (1 mark)

$SO_2 + H_2O \rightarrow H_2SO_3$

(b) Describe two effects of acid rain. (2 marks)

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Sample answer

Acid rain can dissolve $CaCO_3$ and so building materials made of marble can be dissolved by acid rain.
Acid rain can cause leaching of essential nutrients from the soil leading to poor crops.

Marking criteria	Marks
• Describes two effects of acid rain	2
• Identifies two effects of acid rain or • Describes one effect of acid rain	1

Question 14 (2 marks)

Outline two advancements of the Arrhenius theory of acids and bases over the Davy theory of acids and bases.

Sample Answers
Davy: Bases react with acids forming salts and water. Arrhenius: Bases yield hydroxide ions in aqueous solution.

Davy: Acids contain hydrogen that is displaced when reacting with metals. This is a restricted definition of an acid. Arrhenius: Acids yield hydrogen ions. Acids may be strong or weak.

Outcome criteria	*Marks*
Two advantages of Arrhenius theory over Davy's theory stated.	2
One advantage of Arrhenius theory over Davy's theory stated.	1
Only Arrhenius no Davy	1

Question 15 (5 marks)

Standard solutions are used in volumetric analysis.

(a) Identify the accurate glassware in which a standard solution is prepared. (1 mark)

Volumetric flask (1 mark).

(b) 250 mL of a 0.2 $molL^{-1}$ solution of sodium carbonate was prepared.
Calculate the mass of sodium carbonate required to prepare the solution (2 marks).

Sample Answer:

Mol Na_2CO_3 = M x V = 0.2 x 0.25 = 0.05 (1 mark)

Mass Na_2CO_3 = mol x fw = 0.05 x (2(23) + 12 = 3(16)) = 0.05 x 106 = 5.30g (1 mark)

(c) 25.00 mL of this sodium carbonate solution reacted with 24.35 mL of hydrochloric acid.
Calculate the concentration of the acid. (2 marks)

Sample Answer

Na_2CO_3 + 2HCl → 2NaCl + H_2O + CO_2

Mol Na_2CO_3 = M x V = 0.2 x 0.025 = 0.005 (1mark)

mol HCl = 2 x mol Na_2CO_3 = 2 x 0.005 = 0.01

[HCl] = mol /V = 0.01/0.02435 = $molL^{-1}$ (1 mark)

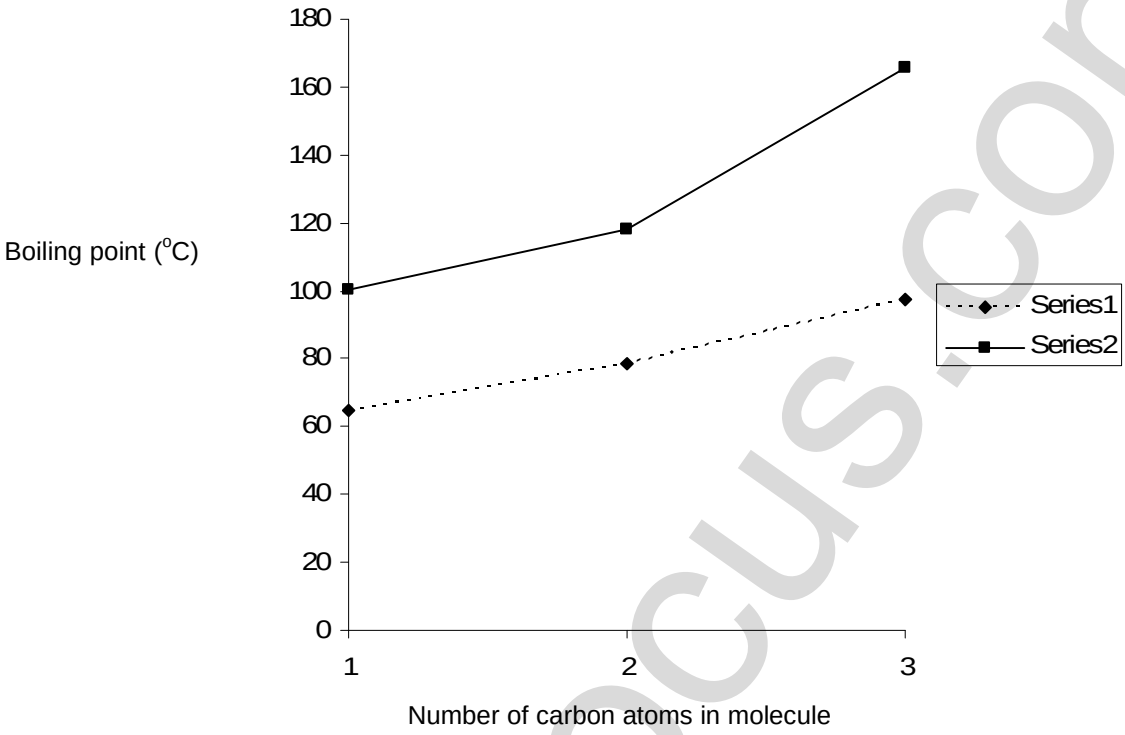
Question 16 (2 marks)

Identify a buffer in a natural system and describe its effects.

The H_2CO_3 / HCO_3^{--} buffer is present in blood. It maintains the pH of the blood by inhibiting changes to the pH. (2 marks)

Question 17 (4 marks)

The boiling points of three alkanoic acids and their equivalent alkanols are presented in the graph. However, the two groups of chemicals have not been identified.



(a) Which group of chemicals is represented by Series 1? Give reasons for your choice.. (2 marks)

Sample answers

(*a*) *Alkanols. (1mark)*

Alkanoic acids have higher boiling points than alkanols due to more extensive hydrogen bonding between their molecules. (1mark)

Outcome criteria	Marks
Stating that alkanoic acids have more extensive hydrogen bonding than alkanols.	1
Recognising Series 1 represents the alkanols.	1

(b) Describe the structural difference between molecules of 1-propanol and propanoic acid. (2 marks)

Answers:

1-propanol (alkanol) has the –OH functional group. (1mark)
Propanoic acid (alkanoic acid) has the –COOH group. (1mark)

Outcome criteria	Marks
Recognising the correct functional group for alkanoic acids: -COOH	1
Recognising the correct functional group for alkanols: -OH	1

Question 18 (2 marks)

Using balanced formulae equations, explain the amphiprotic nature of $H_2PO_4^{1-}$ in aqueous solutions.

Sample Answer

Acidic behaviour: $H_2PO_4^- + OH^- \rightleftharpoons HPO_4^{2-} + H_2O$

Basic behaviour: $H_2PO_4^- + H^+ \rightleftharpoons H_3PO_4$

Outcome criteria	*Marks*
Balanced equation describing the basic behaviour of $H_2PO_4^-$	1
Balanced equation describing the acidic behaviour of $H_2PO_4^-$	1

Question 19 (3 marks)

The odour of the ester that has the following chemical formula is pineapple:

$$CH_3CH_2CH_2COOCH_2CH_3$$

(a) State the name of the ester using IUPAC nomenclature. (1 mark)

Answer ethyl butanoate (1 mark) (or ethyl butyrate)

(b) Write a balanced formulae equation for the reaction that results in the formation of the ester. (2 marks)

Answer

$$CH_3CH_2CH_2COOH + CH_3CH_2OH \rightleftharpoons CH_3CH_2CH_2COOCH_2CH_3 + H_2O$$

Outcome criteria	*Marks*
Balanced equation with correct reactants and correct products	2
Balanced equation with correct reactants or correct products	1

End of Theory Test