Section A: ***Multiple Choice*** (Nos. 1-4, 1-mark each))

Use the multiple choice answer sheet in the ANSWER BOOKLET

1. In an experiment in a particle accelerator with the isotope sodium-24, a neutron is captured by the Na-24 nucleus, forming a new isotope of sodium. This new isotope decays by alpha particle emission, producing a daughter nucleus. The daughter nucleus is:
   A. aluminium-28
   B. fluorine-21
   C. neon-20
   D. fluorine-20

2. Which of the following is a conjugate acid/base pair?

   A. H_3O^+ and OH^-
   B. HNO_3 and H_2O
   C. HNO_3 and HNO_2
   D. HNO_3 and NO_3^-

3. Which of the following pairs of equations show the amphiprotic behaviour of H_2A^-

	Reaction 1	Reaction 2
A	$H_2A^- + H_3O^+ \rightleftharpoons H_3A + H_2O$	$H_2A^- + H_2O \rightleftharpoons H_3A + OH^-$
B	$H_2A^- + H_3O^+ \rightleftharpoons H_3A + H_2O$	$H_2A^- + OH^- \rightleftharpoons HA^{2-} + H_2O$
C	$H_2A^- + OH^- \rightleftharpoons H_3A + H_2O$	$H_2A^- + H_2O \rightleftharpoons H_3A + OH^-$
D	$H_2A^- + H_2O \rightleftharpoons HA^{2-} + H_3O^+$	$H_2A^- + OH^- \rightleftharpoons HA^{2-} + H_2O$

4. Use Le Chatelier's principle to predict the effect of various factors on the Haber process of ammonia production.

	Increase temperature	Increase pressure	Include catalyst
A	rate decreased	rate increased	rate increased
B	rate increased	rate decreased	rate not affected
C	yield increased	yield increased	yield increased
D	yield reduced	yield increased	no effect on yield

Answer Booklet for Sections A and B **Student No.....**

INSTRUCTIONS

Use the multiple choice answer sheet below.

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

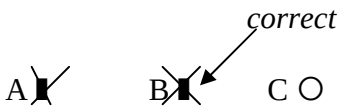
Sample 2+4= (A) 2 (B) 6 (C) 8 (D)9

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 this by writing the word *correct* and drawing an arrow as follows:



Section A

Multiple Choice Answer Sheet

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

Section B. *Answer the questions in the spaces provided. Show all relevant working in questions involving calculations* **MARKS**

Question 5 (5 marks)

In water there is an equilibrium between gaseous and dissolved carbon dioxide according to the equation,

$$CO_2\,(g) \rightleftharpoons CO_2(aq)$$

The dissolving process is exothermic. A series of equilibrium reactions occur as the dissolved carbon dioxide reacts with water.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$
$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$$
$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$$

a) Explain in terms of Le Chatelier's Principle why

i) fizzing occurs when a bottle of soft drink is opened? **1**

.....

.....

.....

.....

ii) a"flat" soft drink (ie from which all the bubbles escaped) has a higher pH than a newly opened bottle. **1**

.....

.....

b) A student measured the mass of carbon dioxide dissolved in a bottle of soft drink by weighing the bottle before opening and after all the gas had been liberated from solution. The measured mass change was 3.52g. Calculate the volume of carbon dioxide liberated at 25 ^{0}C and 101.3kPa. **2**

.....

.....

.....

c) When excess carbon dioxide in the atmosphere dissolves in water, it can form acid rain. Describe one effect of acid rain. **1**

.....

Student No.....

Question 6 (3 marks**)** **MARKS**

The salt, sodium hydrogen phosphate (Na_2HPO_4) can be prepared by reacting sodium hydroxide solution with the required amount of phosphoric acid (H_3PO_4) solution.

a) Write a balanced equation for the reaction. **1**

.....

b) When some crystals of Na_2HPO_4 were dissolved in water, the pH of the resulting solution was found to be 9.5. Calculate the hydrogen ion concentration of this solution. **1**

.....

.....

c) Write an equation for the reaction of the HPO_4^{2-} ion with water to account for the measured pH. **1**

.....

Question 7 (3 marks)

a) Give a balanced chemical equation to illustrate the process of esterification of methanoic acid with ethanol. **1**

.....

b) Explain the need for refluxing during esterification. **2**

.....

.....

.....

.....

Question 8. (5 marks) **MARKS**

A student tests the pH of three different monoprotic acid solutions of known concentrations. The results are shown in the table.

Monoprotic acid	Acid concentration (mol L^{-1})	Tested pH
HX	1.0	2.4
HY	0.02	1.7
HZ	0.5	2.3

a) Outline what a weak acid is according to the Bronsted-Lowry theory. **1**

.....

.....

b) Which of the acids tested is the weakest acid based on your answer in (a)? **1**

.....

..

c) Write an ionic equation showing the ionisation of HX in water. **1**

.....

d) Which of the acids can be classified as a strong acid? Perform a simple calculation to support your answer. **1**

.....

.....

.....

e) Name (i)an example of a weak, naturally occurring acid and (ii)a strong, manufactured acid. **1**

(i).....

(ii).....

Student No. .....

Question 9 (5 marks) **MARKS**

a. Outline the Lewis definition of an acid. **1**

.....

.....

b. A solution of sodium hydroxide is to be standardised with solid potassium hydrogen phthalate (KHP), a weak monoprotic acid. Outline the main steps required in the standardisation process, mentioning the main apparatus required for the process. **3**

.....

.....

.....

.....

.....

.....

.....

c.. Describe the role of a buffer in maintaining the pH of a named natural system. **1**

.....

.....

.....

.....

END OF TASK

Section A: ***Multiple Choice*** (Nos. 1-4, 1-mark each))

Use the multiple choice answer sheet in the ANSWER BOOKLET

1. In an experiment in a particle accelerator with the isotope sodium-24, a neutron is captured by the Na-24 nucleus, forming a new isotope of sodium. This new isotope decays by alpha particle emission, producing a daughter nucleus. The daughter nucleus is:
   A. aluminium-28
   B. fluorine-21
   C. neon-20
   D. fluorine-20

2. Which of the following is a conjugate acid/base pair?

   A. H_3O^+ and OH^-
   B. HNO_3 and H_2O
   C. HNO_3 and HNO_2
   D. HNO_3 and NO_3^-

3. Which of the following pairs of equations show the amphiprotic behaviour of H_2A^-

	Reaction 1	Reaction 2
A	$H_2A^- + H_3O^+ \rightleftharpoons H_3A + H_2O$	$H_2A^- + H_2O \rightleftharpoons H_3A + OH^-$
B	$H_2A^- + H_3O^+ \rightleftharpoons H_3A + H_2O$	$H_2A^- + OH^- \rightleftharpoons HA^{2-} + H_2O$
C	$H_2A^- + OH^- \rightleftharpoons H_3A + H_2O$	$H_2A^- + H_2O \rightleftharpoons H_3A + OH^-$
D	$H_2A^- + H_2O \rightleftharpoons HA^{2-} + H_3O^+$	$H_2A^- + OH^- \rightleftharpoons HA^{2-} + H_2O$

4. Use Le Chatelier's principle to predict the effect of various factors on the Haber process of ammonia production.

	Increase temperature	Increase pressure	Include catalyst
A	rate decreased	rate increased	rate increased
B	rate increased	rate decreased	rate not affected
C	yield increased	yield increased	yield increased
D	yield reduced	yield increased	no effect on yield

Answer Booklet for Sections A and B **Student No.....*Possible Answers*.....**

INSTRUCTIONS

Use the multiple choice answer sheet below.

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

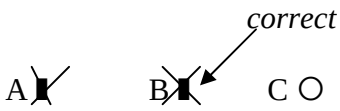
Sample 2+4= (A) 2 (B) 6 (C) 8 (D)9

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 this by writing the word *correct* and drawing an arrow as follows:



Section A

Multiple Choice Answer Sheet

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

Section B. *Answer the questions in the spaces provided. Show all relevant working in questions involving calculations* **MARKS**

Question 5 (5 marks)

In water there is an equilibrium between gaseous and dissolved carbon dioxide according to the equation,

$$CO_2\,(g) \rightleftharpoons CO_2(aq)$$

The dissolving process is exothermic. A series of equilibrium reactions occur as the dissolved carbon dioxide reacts with water.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$
$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$$
$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$$

a) Explain in terms of Le Chatelier's Principle why

i) fizzing occurs when a bottle of soft drink is opened? **1**

.....Opening the bottle causes a decrease in pressure . Equilibrium will shift to to oppose that change, i.e., to increase the pressure & make more gas... . (shift to left above). As the gas leaves the liquid, it "fizzes"

.....

ii) a"flat" soft drink (i.e. from which all the bubbles escaped) has a higher pH than a newly opened bottle. **1**

As CO_2 is removed from the liquid, H_2CO_3 is removed

. ∴ less H_3O^+ in the liquid means a higher pH.

b) A student measured the mass of carbon dioxide dissolved in a bottle of soft drink by weighing the bottle before opening and after all the gas had been liberated from solution. The measured mass change was 3.52g. Calculate the volume of carbon dioxide liberated at 25 ^{0}C and 101.3kPa. **2**

.....mol CO_2 = mass/FW = 3.52/44 = 0.0800 mole

.....

$V\,CO_2$ = mol x 24.5 = 0.08 x 24.5 = 1.96 L

.....

c) When excess carbon dioxide in the atmosphere dissolves in water, it can form acid rain. Describe one effect of acid rain. **1**

- *increasing acidity of lakes*
- *erosion of marble bldg surfaces*
- *damage to pine forests*

Student No.....

Question 6 (3 marks**)** **MARKS**

The salt, sodium hydrogen phosphate (Na_2HPO_4) can be prepared by reacting sodium hydroxide solution with the required amount of phosphoric acid (H_3PO_4) solution.

a) Write a balanced equation for the reaction. **1**

$2\ NaOH + H_3PO_4 \rightarrow Na_2HPO_4 + 2\ H_20(l)$.

b) When some crystals of Na_2HPO_4 were dissolved in water, the pH of the resulting solution was found to be 9.5. Calculate the hydrogen ion concentration of this solution. **1**

$[H^+.] = 10^{-pH}.$; $[H^+] = 10^{-9.5} = 3.2 \times 10^{-10}\ mol\ L^{-1}$

.....

c) Write an equation for the reaction of the HPO_4^{2-} ion with water to account for the measured pH. **1**

$HPO_4^{2-} + H_2O(l) \rightleftharpoons H_2PO_4^- + OH^-$

.....

Question 7 (3 marks)

a) Give a balanced chemical equation to illustrate the process of esterification of methanoic acid with ethanol. **1**

$HCOOH + CH_3CH_2OH \xrightarrow[conc.\ H_2SO_4]{} HCOOCH_2CH_3 + H_2O$

b) Explain the need for refluxing during esterification. **2**

Esterification is a slow process which can be hastened with heating
Refluxing allows the reaction mixture to be heated without the loss of volatile constituents

Question 8. (5 marks) **MARKS**

A student tests the pH of three different monoprotic acid solutions of known concentrations. The results are shown in the table.

Monoprotic acid	Acid concentration (mol L^{-1})	Tested pH
HX	1.0	2.4
HY	0.02	1.7
HZ	0.5	2.3

a) Outline what a weak acid is according to the Bronsted-Lowry theory. **1**

A weak acid would donate a proton with difficulty or incompletely,

..low percentage ionisation.

b) Which of the acids tested is the weakest acid based on your answer in (a)? **1**

.....*HX*.....

..

c) Write an ionic equation showing the ionisation of HX in water. **1**

$HX + H_2O \rightleftharpoons H_3O^+ + X^-$

d) Which of the acids can be classified as a strong acid? Perform a simple calculation to support your answer. **1**

HY, because [HY] = [H^+]
i.e. 100% ionised .....

pH = -log [H^+] = -log 0.02 mol L^{-1} = 1.7.

e) Name (i)an example of a weak, naturally occurring acid and (ii)a strong, manufactured acid. **1**

(i).....*H_2CO_3*.....

(ii). *H_2SO_4*.....
.....

Student No. .....

Question 9 (5 marks) **MARKS**

a. Outline the Lewis definition of an acid. **1**

Lewis acid is an electron pair acceptor.....

b. A solution of sodium hydroxide is to be standardised with solid potassium hydrogen phthalate (KHP), a weak monoprotic acid. Outline the main steps required in the standardisation process, mentioning the main apparatus required for the process. **3**

The solid KHP is accurately weighed in an analytical balance. The substance is then dissolved and then accurately diluted to volume using a volumetric flask. A known aliquot is pipetted (using a delivery pipette) into a conical flask and then titrated with the NaOH to be standardised, contained in a burette. A suitable (phenolphthalein) indicator is used to determine the equivalence point.

c.. Describe the role of a buffer in maintaining the pH of a named natural system. **1**

In blood, the pH is maintained by the presence of HCO_3^- which can accept a proton should $[H^+]$ increases and the presence of H_2CO_3 which can donate a proton should $[H^+]$ decreases

END OF TASK