Answers
and
Marking Scheme

Chemistry

HSC Course

Acidic Environment + Industrial Chemistry

Theory Test • 2007

Part A – 12 marks
Attempt Questions 1 – 12
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.

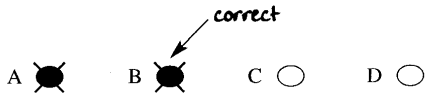
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



Answer Box for Questions 1 – 12

1	**A** ○	**B** ○	**C** ●	**D** ○
2	**A** ○	**B** ○	**C** ○	**D** ●
3	**A** ○	**B** ○	**C** ○	**D** ●
4	**A** ●	**B** ○	**C** ○	**D** ○
5	**A** ○	**B** ○	**C** ○	**D** ●
6	**A** ○	**B** ○	**C** ○	**D** ●
7	**A** ○	**B** ○	**C** ●	**D** ○
8	**A** ●	**B** ○	**C** ○	**D** ○
9	**A** ○	**B** ○	**C** ●	**D** ○
10	**A** ○	**B** ●	**C** ○	**D** ○
11	**A** ○	**B** ●	**C** ○	**D** ○
12	**A** ●	**B** ○	**C** ○	**D** ○

1 Which of the following substances is a natural source of atmospheric NO_2?

(A) combustion of coal
(B) combustion of unleaded petrol
(C) lightning storm
(D) volcanoes

2 Which of the following is the correct IUPAC name for citric acid?

(A) 2–hydroxypropanoic acid
(B) 1,2,3–tripropanoic acid
(C) hydroxypropane carboxylic acid
(D) 2–hydroxypropane–1,2,3–tricarboxylic acid

3 Which of the following would be the most appropriate chemical to neutralise a small amount of acid spilt on a lab benchtop.

(A) CH_3COOH
(B) H_2O
(C) NaOH
(D) $NaHCO_3$

4 A pigment from violet flowers is purple in acidic solutions, yellow in alkaline solutions and colourless in neutral solutions. In which of the following would you expect the pigment to show no colour?

(A) a solution of sodium chloride
(B) white vinegar
(C) household ammonia (cleaning agent)
(D) lemonade (colourless lemonade)

5 Which of the following substance will have the lowest boiling point?

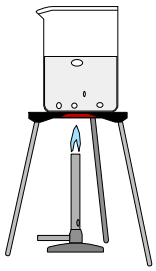
(A) HCOOH
(B) CH_3OH
(C) H_2O
(D) CH_4

6 Identify the main product of the reaction between $CH_3(CH_2)_4COOH$ and CH_3CH_2OH.

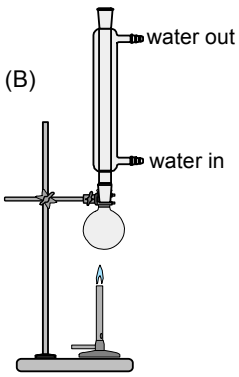
(A) pentyl ethanoate
(B) ethyl butanoate
(C) hexyl ethanoate
(D) ethyl hexanoate

7 Which of the set–ups below is most appropriate to produce esters in the laboratory?

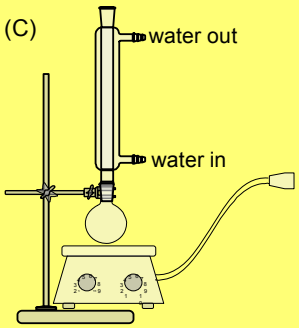
(A)



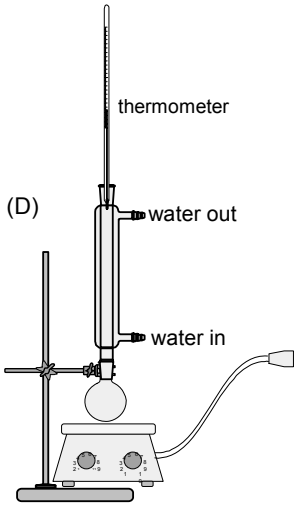
(B)



(C)



(D)



8 Which of the following best describes a 2.0 mol L^{-1} solution of acetic acid?

(A) a concentrated solution of a weak acid
(B) a weak solution of a dilute acid
(C) a strong solution of a concentrated acid
(D) a dilute solution of a strong acid

9 Which of the following chemists proposed that all acids contain hydrogen?

(A) Arrhenius
(B) Brønsted
(C) Davy
(D) Lavoisier

10 What is the pH of 3.6×10^{-3} mol L^{-1} HNO_3 ?

(A) 0.0036
(B) 2.44
(C) 3.60
(D) 5.63

11 The table shows the colour ranges of several indicators.

Indicator	low range colour	pH of transition range	high range colour
thymol blue	red	1.2 – 2.8	yellow
bromophenol blue	yellow	3.0 – 4.6	blue
methyl orange	red	3.1 – 4.4	yellow
methyl red	red	4.8 – 6.0	yellow
litmus	red	4.7 – 8.2	blue
thymol blue	yellow	8.0 – 9.6	blue
phenolphthalein	colourless	8.3 – 10.0	red

The results of testing a substance with three of the indicators are shown in the table.

Indicator added to substance	*Result (final colour of indicator)*
methyl orange	red
thymol blue	yellow
phenolphthalein	colourless

Which is a possible pH of the substance?

(A) 1
(B) 3
(C) 4.5
(D) 8

12 What is the purpose of concentrated sulfuric acid in the esterification reaction?

(A) To speed up the attainment of equilibrium
(B) To shift the equilibrium to the left
(C) To increase the yield of ester
(D) To increase the activation energy of the reaction

13 Cloudy ammonia (a household cleansing product) is a solution of ammonia in water which is excellent for cleaning glass. The Amalgamated Ammonia Company regularly tests the concentration of its manufactured cloudy ammonia by a simple acid–base titration using standardised sulfuric acid.

(a) Write the balanced chemical equation for the neutralisation of cloudy ammonia by sulfuric acid. **(1 mark)**

$2NH_{3\,(aq)} + H_2SO_{4\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$
► ***$NH_{3\,(aq)} + H_2SO_{4\,(aq)} \rightarrow NH_4^+{}_{(aq)} + HSO_4^-{}_{(aq)}$ was also accepted***

(b) Suggest a suitable indicator for this acid–base titration and justify your answer. **(2 marks)**

Methyl orange (3.1 – 4.4), methyl red (4.4 – 6.2), bromophenol blue (3 – 4.6) would be suitable indicators, since the pH at the equivalence point is acidic, a result of the acidic nature of the salt formed, $(NH_4)_2SO_4$.

► **Bromothymol blue (6 – 7.6) not acceptable due to a large end point error.**

► **Correct indicator stated = 1 mark**

► **"… acidic salt formed …" = 1 mark**

(c) A lab technician analyses a sample of cloudy ammonia from the production line.
The table shows the titration data.

Concentration of standardised H_2SO_4	0.155 mol L^{-1}
Average titre of standardised H_2SO_4	47.4 mL
Aliquot of cloudy ammonia	5.00 mL

Calculate the concentration of cloudy ammonia. **(2 marks)**

mol H_2SO_4 = c V = 0.155 mol L^{-1} × 0.0474 L = 7.347×10^{-3}

mol NH_3 = 2 × mol mol H_2SO_4 = 1.469×10^{-2}

[NH_3] = mol ÷ V = 1.469×10^{-2} ÷ 0.00500 L = 2.9388 = 2.94 mol L^{-1}

► **Correct calculation of moles of NH_3 = 1 mark**

► **Divide by 0.00500 L = 1 mark**

► **Flow on error from student's equation provided in (a) was accepted if the equation provided was incorrect.**

14 The reaction of hydrogen chloride gas with ammonia gas,

$$HCl\,(g) + NH_3\,(g) \rightarrow NH_4Cl\,(s)$$

is classified as an acid /base reaction according to Brønsted/Lowry theory, but not according to Arrhenius' theory of acids and bases.

Justify this statement. **(3 marks)**

Sample Answer

Arrhenius proposed that acids are substances that produce hydrogen ions in water and bases were substances that dissociated in water to produce hydroxide ions. This would not be an Arrhenius acid/base reaction because no hydroxide ions are produced. Brønsted/Lowry defined acids as proton donors and bases as proton acceptors.
In this case, HCl donates a proton and NH_3 accepts a proton so is an acid/base reaction.

Marking criteria	Marks
Describes both acid theories and explains why this is an acid/base reaction.	3
Describes Brønsted/Lowry theory and explains why this is an acid /base reaction	2
Correctly defines acids according to Arrhenius or Brønsted/Lowry	1

15 (a) Identify the following salts as acidic, basic or neutral. **(2 marks)**

Salt	*Acidic, basic or neutral solution*
NaCl	***neutral***
NH_4Cl	***acidic***
$NaHCO_3$	***basic***
KCH_3COO	***basic***

(b) Give an equation to show the action of an acidic salt in (a), in water. **(1 mark)**

$$\mathbf{NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+}$$

(c) Identify one conjugate acid/base pair in the reaction given in (b) above. **(1 mark)**

$$\mathbf{NH_4^+ / NH_3}$$

(d) Identify an amphiprotic ion present in one of the salts listed in the table. **(1 mark)**

$$\mathbf{HCO_3^-}$$

16 Atmospheric oxides of sulfur have been increasing over the last 150 years.

(a) Assess the impact of this trend and include relevant balanced equations in your answer. **(5 marks)** ► *Do not reproduce the reaction from part (b) below.*

(b) Copper may be extracted from copper(II) sulfide ore by roasting it in oxygen. Copper(II) oxide and sulfur dioxide are produced.

What volume of sulfur dioxide is produced when 191 g of copper(II) sulfide is roasted? (Volume measured at 25°C and 100 kPa). **(2 marks)**

Sample answer

(a) ***There has been a rapid increase in atmospheric SO_2 over the last 150 years due to the industrial revolution which caused the increased burning of coal and the release of SO_2 from metal smelting.***

$S + O_2 \rightarrow SO_2$

The consequence of an increase on the SO_2 has been an environmental problem called acid rain.

$SO_2 + H_2O \rightarrow H_2SO_3$

This acid rain has caused widespread deforestation and damage to buildings and waterways. The impact has been great and has led to legislation to minimize the output of SO_2 into the atmosphere by industry.

Marking criteria	Marks
All of 4 and a judgement	5
One or two equations and a description of acid rain and its consequences	3 – 4
Two equations or one equation and acid rain	2
One equation or acid rain	1

(b) ***mol CuS = 2.00 mol*** ***(1 mark)***

V SO_2 = 49.5 L ***(1 mark)***

17 A primary standard solution was prepared by dissolving 0.316 g of hydrated oxalic acid, $(COOH)_2 \bullet 2H_2O$ in water and making the solution up to 250.0 mL

(a) Calculate the concentration of the solution. **(2 marks)**

mol $(COOH)_2 \bullet 2H_2O$ = 2.5066 x 10^{-3}

[$(COOH)_2 \bullet 2H_2O$] = 0.0100 mol L^{-1}

(b) Identify the piece of accurate glassware in which this solution is prepared. **(1 mark)**

volumetric flask

18 An organic acid and an alcohol were allowed to react using the appropriate apparatus, producing an ester and water.

$$\text{organic acid} + \text{alkanol} \underset{\text{conc. } H_2SO_4}{\rightleftharpoons} \text{ester} + \text{water} \quad \Delta H = -58 \text{ kJ mol}^{-1}$$

Certain changes are then made to this mixture. Considering each separately, state the effect that the change has on the equilibrium position by completing the table. **(2 marks)**

Change/Stress	*Effect on the equilibrium position*
(a) raising the temperature	***shifts to the left***
(b) increasing the pressure above the solution	***no effect***
(c) adding alkanol to the mixture	***shifts to the right***
(d) adding a base	***shifts to the left***

19 Selected students from Hiuai High School were assigned to plan and perform an experiment to decarbonate a cola drink. Detailed below are the steps they took to address the problem.

- Placed a pre-weighed 400 mL beaker on a warm hot plate.
- Unscrewed a 375 mL bottle of JR cola and carefully transferred the contents to the beaker.
- The beaker was weighed immediately after transfer and weighed every 2 minutes thereafter.
- At intervals between weighings, the beaker was kept on the hot plate and stirred with a thermometer to monitor the temperature which was kept at 60°C for 10 minutes.

Assess the validity of the procedure. **(3 marks)**

Criteria	*Mark*
2 mistakes in the procedure	2
final assessment (judgement)	1

Possible Answer

The following mistakes were committed by the students making their procedure invalid:

- ***the original mass of the cola was not recorded***
- ***the cola was heated resulting in possible loss of water in addition to the loss of CO_2***
- ***the method followed would not allow the sample to be weighed to constant mass***

20 Identify a non-fossil fuel natural product and the issues associated with the need to replace this natural product. Assess the viability of a possible replacement with respect to the issues. **(4 marks)**

Criteria	*Mark*
Identification of a non-fossil fuel natural product and replacement	2
Viability of the replacement with respect to the issues (for and against)	2

Possible Answer

- ***A natural product that may require replacement is the anti-malarial drug, Quinine.***
- ***Quinine is extracted from the bark of the cinchona tree, which remains to be the only viable source of Quinine. Synthetic quinine was produced in the 1940s but this could not compete in economic terms with that produced naturally.***
- ***The supply of quinine, was limited by the availability of the cinchona tree and a synthetic replacement was required.***
- ***Chloroquine is a synthetic drug which can be produced in bulk to replace quinine in the treatment of malaria.***
- ***However, in recent years increasing resistance to chloroquine has been developed by certain strains of plasmodium, the mosquito parasite which causes malaria.***
- ***Natural quinine extracted from quinine bark and the use of natural bark tea and/or bark extracts are making a comeback in the management and treatment of malaria.***