



Mercedes College

ASPIRE EXCEL LEAD

ATAR CHEMISTRY

Semester 1 2017

Question/Answer booklet

Name: _____

Teacher: _____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: ten minutes

Working time for the paper: three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Book

To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	/50	/25
Section Two: Short answer	10	10	60	/70	/35
Section Three: Extended answer	6	6	70	/80	/40
					/100

Instructions to candidates

1. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each questions shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
 - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
 - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.
5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

Section One: Multiple-choice**25% (50 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

1. In a chemical reaction at constant temperature, the addition of a catalyst:
- (a) increases the concentration of the products at equilibrium.
 - (b) increases the energy of the molecules so more can successfully collide.
 - (c) lowers the amount of energy released in the overall reaction.
 - (d) decreases the time required for equilibrium to be reached.
2. Consider the information in the table below regarding three different monoprotic acids.

Acid	K_a
Formic acid	1.82×10^{-4}
Hydrofluoric acid	6.76×10^{-4}
Propionic acid	1.35×10^{-5}

If separate 0.5 mol L^{-1} solutions of these three acids were tested with a pH meter, at the same temperature, which would have the highest pH?

- (a) Formic acid.
 - (b) Hydrofluoric acid.
 - (c) Propionic acid.
 - (d) More information is required.
3. The conjugate base of the acid HPO_3^{2-} is:
- (a) H_2PO_3^-
 - (b) PO_3^{2-}
 - (c) H_3PO_3
 - (d) PO_3^{3-}
4. The following statements refer to the chemical reaction between magnesium carbonate granules, (MgCO_3) and a dilute hydrochloric acid solution, (HCl). Which one of the following statements about this reaction is FALSE?
- (a) The rate of the reaction decreases with increasing time.
 - (b) The rate of reaction increases with increasing initial temperature.
 - (c) The rate of reaction increases with increasing initial concentration of HCl (aq).
 - (d) The initial rate of reaction is independent of the state of sub-division of MgCO_3 (s).

Questions 5 and 6 relate the following information:

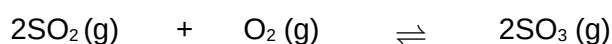
Consider the following information for a 1.00 mol L⁻¹ solution of arsenous acid, (H₃AsO₄):



$$K_a (\text{at } 25^\circ\text{C}) = \frac{[\text{H}^+][\text{H}_2\text{AsO}_4^-]}{[\text{H}_3\text{AsO}_4]} = 6.6 \times 10^{-10}$$

5. At equilibrium at 25°C, which of the following species will be present in the greatest concentration?
- (a) H⁺ (aq)
 - (b) H₂AsO₄⁻ (aq)
 - (c) H₃AsO₄ (aq)
 - (d) OH⁻ (aq)
6. Which of the following statements best describe the value of the equilibrium constant (K) for arsenous acid at 25°C?
- (a) Arsenous acid is a strong acid existing essentially as molecules.
 - (b) Arsenous acid is a weak acid existing essentially as molecules.
 - (c) Arsenous acid is a weak acid existing essentially as ionic species.
 - (d) Arsenous acid is strong acid existing essentially as ionic species.
7. The pH of a solution was measured with a pH meter during a titration, and was observed to decrease from 4.0 to 2.0. Which of the following statements about the hydrogen ion concentration in the solution is correct?
- (a) It doubled.
 - (b) It decreased by half.
 - (c) It increased by a factor of 100.
 - (d) It decreased by a factor of 100.

8. Which one of the following statements about the following reversible reaction is TRUE?



- (a) $K = \frac{[\text{SO}_2]^2 [\text{O}_2]}{[\text{SO}_3]^2}$
- (b) K is constant under all reaction conditions.
- (c) Sulfur trioxide is being formed when the reaction is at equilibrium.

See next page

(d) A catalyst increases the yield of sulfur trioxide by increasing ΔH .

9. In which of the following reactions at equilibrium and at constant temperature is there a shift to the "left" if the pressure of the closed system is increased?

- (a) $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
 (b) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
 (c) $\text{H}_2\text{O}(\text{g}) + \text{C}(\text{s}) \rightleftharpoons \text{H}_2(\text{g}) + \text{CO}(\text{g})$
 (d) $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2\text{HF}(\text{g})$

10. Bromophenol blue is an acid-base indicator that has a colour change from yellow to blue between pH 3.0 and 4.6. A potassium hydroxide solution (in a conical flask), containing a few drops of bromophenol blue indicator, is titrated with an acetic (ethanoic) acid solution (from a burette).

Which one of the following statements about this titration is true?

- (a) The end point and the equivalence point occur at the same time.
 (b) The end point occurs after the equivalence point.
 (c) The end point occurs before the equivalence point.
 (d) The indicator will be yellow at the equivalence point of the titration.

11. A student had five different 0.2 mol L⁻¹ solutions on her lab bench. They were;

- nitric acid, $\text{HNO}_3(\text{aq})$
- zinc chloride, $\text{ZnCl}_2(\text{aq})$
- lithium hydrogencarbonate, $\text{LiHCO}_3(\text{aq})$
- potassium hydroxide, $\text{KOH}(\text{aq})$
- ammonium chloride, $\text{NH}_4\text{Cl}(\text{aq})$

Rank these solutions in order of **increasing** pH (i.e. lowest to highest).

- (a) $\text{HNO}_3 < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{KOH}$
 (b) $\text{KOH} < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{HNO}_3$
 (c) $\text{HNO}_3 < \text{LiHCO}_3 < \text{NH}_4\text{Cl} < \text{ZnCl}_2 < \text{KOH}$
 (d) $\text{KOH} < \text{ZnCl}_2 < \text{LiHCO}_3 < \text{NH}_4\text{Cl} < \text{HNO}_3$

12. Calculate the pH of a solution formed by mixing 10.0 mL of 0.125 mol L⁻¹ nitric acid, $\text{HNO}_3(\text{aq})$, with 90.0 mL of water.

- (a) 2.90
 (b) 1.86
 (c) 0.90
 (d) 1.90

13. Which choice correctly describes the properties of aqueous solutions of the following salts?

	Sodium ethanoate (NaCH_3COO)	Potassium nitrate (KNO_3)	Ammonium chloride (NH_4Cl)
(a)	neutral	acidic	basic
(b)	basic	acidic	acidic
(c)	acidic	neutral	basic
(d)	basic	acidic	neutral

14. Household bleach contains sodium hypochlorite, NaClO, as the active ingredient. The concentration of NaClO in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H₂O₂, according to the equation:



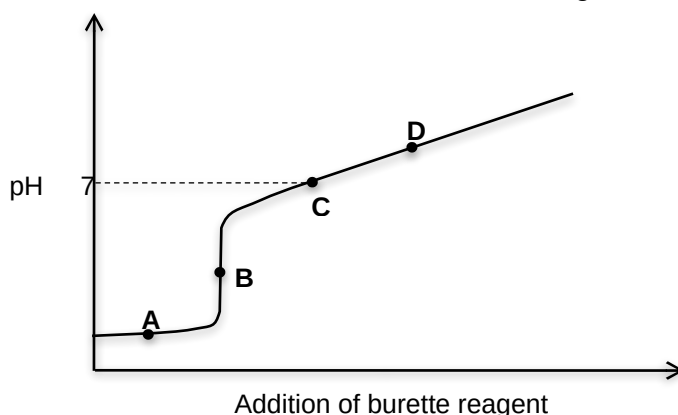
When 25.0 mL of bleach is treated with an excess of aqueous H₂O₂, 0.0350 mol of oxygen gas is given off.

What is the concentration of NaClO in the bleach?

- (a) 1.40 mol L⁻¹
- (b) 0.700 mol L⁻¹
- (c) 0.875 mol L⁻¹
- (d) 8.75 × 10⁻⁴ mol L⁻¹

Questions 15 and 16 refer to the information below.

An acid-base titration was conducted by a chemistry professor, with the pH being monitored throughout the experiment. From the data collected, the following titration curve was produced.



15. Which of the following arrangements could have produced this titration curve?

	Burette reagent	Conical flask reagent
(a)	HNO ₃ (aq)	KOH(aq)
(b)	NH ₃ (aq)	HCl(aq)
(c)	NaOH(aq)	CH ₃ COOH(aq)
(d)	HCl(aq)	Na ₂ CO ₃ (aq)

16. Which letter represents the equivalence point of the titration?

- (a) A
- (b) B
- (c) C
- (d) D

17. Hydrogen can be produced by the steam reforming of methane as in the following reaction:



Which one of the following will increase the equilibrium yield of hydrogen?

- (a) Increasing the total pressure of the reaction system.
- (b) Decreasing the partial pressure of the water vapour.
- (c) Removing the carbon monoxide from the system as it is produced.
- (d) Decreasing the temperature of the system.

18. Which of the following combinations will form a buffer solution?

- i. $\text{NH}_3(\text{aq}) / \text{NH}_4\text{Cl}(\text{aq})$
 - ii. $\text{NH}_3(\text{aq}) / \text{HCl}(\text{aq})$
 - iii. $\text{HCl}(\text{aq}) / \text{NH}_4\text{Cl}(\text{aq})$
 - iv. $\text{H}_2\text{PO}_4^-(\text{aq}) / \text{HPO}_4^{2-}(\text{aq})$
 - v. $\text{H}_2\text{SO}_4(\text{aq}) / \text{HSO}_4^-(\text{aq})$
- (a) i and iv only
 - (b) i, iv and v only
 - (c) i, ii and iv only
 - (d) iv only

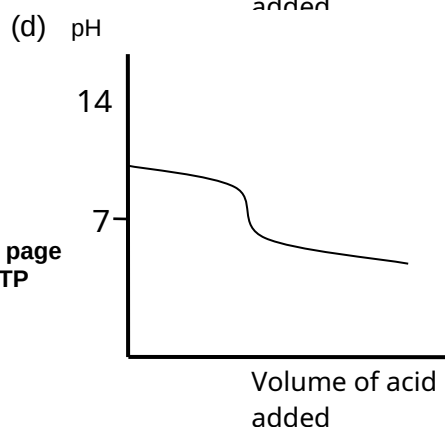
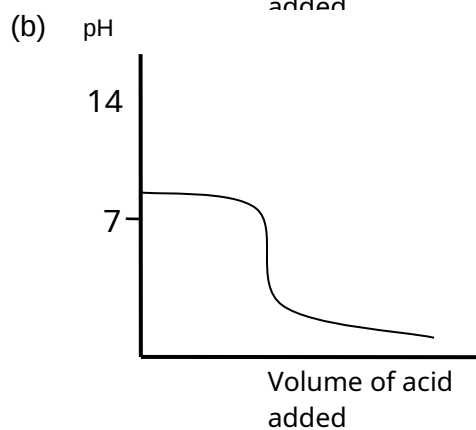
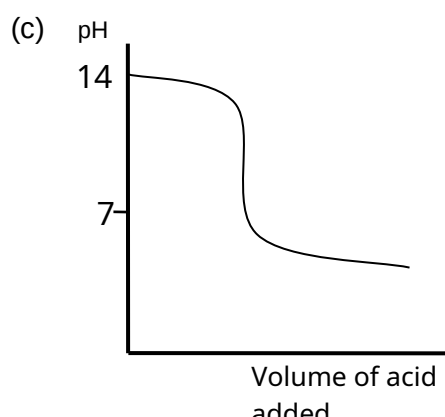
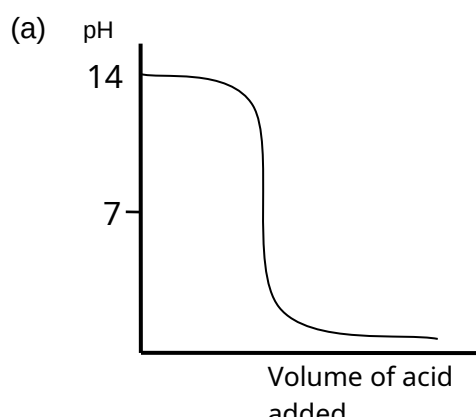
Questions 19, 20 and 21 relate the following information:

A student was asked to determine the concentration of a solution of ethanoic acid that had a concentration of approximately 0.400 mol L^{-1} . He pipetted 20.0 mL of a 0.500 mol L^{-1} solution of sodium hydroxide into a conical flask, and titrated the ethanoic acid against the standardised sodium hydroxide solution, using phenolphthalein as the indicator.

19. What is the pH of the sodium hydroxide solution at the start of the titration?

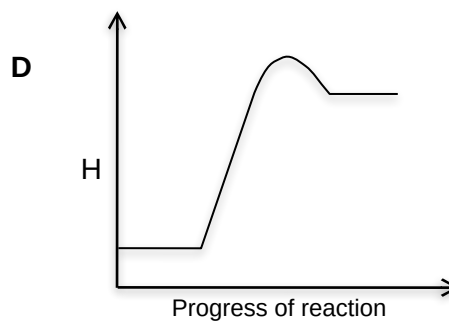
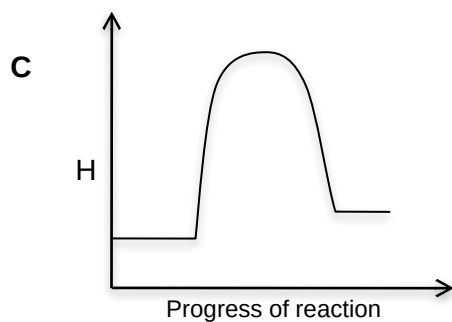
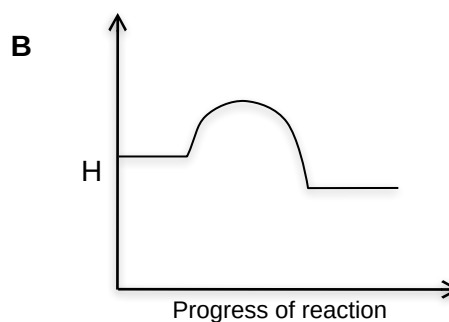
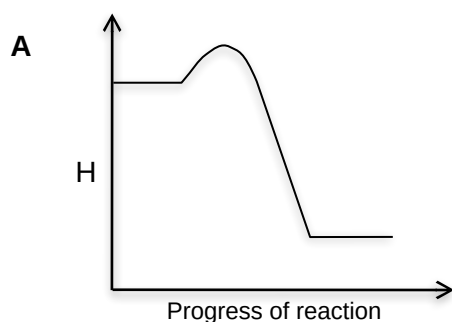
- (a) 13.7
- (b) 7.00
- (c) 14.0
- (d) 12.7

20. If the ethanoic acid was added until it was slightly in excess, which of the following pH graphs would show the variation of pH during the titration?



See next page
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21. What approximate volume of ethanoic acid would the student expect to have added at the end point of the titration?
- (a) 20 mL
(b) 30 mL
(c) 25 mL
(d) 35 mL
22. Examine the following energy profile diagrams, which represent four different chemical processes. You may assume the scale on the y-axis is the same for each diagram.

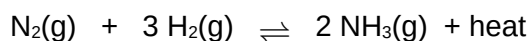


Considering the forward and reverse activation energies of these reactions, which is **most likely** to be a reversible reaction (i.e. the reaction that is most likely to proceed in both the forward and reverse directions)?

- (a) A
(b) B
(c) C
(d) D

Questions 23 and 24 refer to the information below.

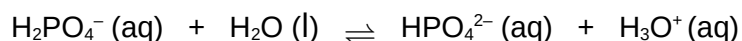
The Haber process is the final step in the production of ammonia. It involves the reaction of nitrogen and hydrogen gases in the presence of an iron/iron oxide catalyst. This process is carried out at 350-550 °C and 15-35 MPa. The reaction can be represented by the equation below.



23. Which statement is **not** correct regarding the action of a catalyst?
- (a) A catalyst increases the rate of reaction.
 - (b) A catalyst increases the average kinetic energy of the reactant particles.
 - (c) A catalyst allows a greater proportion of particles to react.
 - (d) A catalyst provides an alternate reaction pathway.
24. If the equilibrium system **temperature** is increased, what effect will this have on the equilibrium constant, K, and the yield?

	Equilibrium constant, K	Yield increase
(a)	decrease	products
(b)	increase	products
(c)	decrease	reactants
(d)	increase	reactants

25. Consider the buffer solution represented by the chemical reaction below:



Which of the following would be **true** after the addition of a small volume of 2.0 mol L⁻¹ sodium hydroxide solution to the buffer solution?

- (a) The forward reaction rate would be unaffected.
- (b) The concentration of H₂PO₄⁻ (aq) present in the system would increase.
- (c) The pH of the system would decrease.
- (d) The equilibrium would shift to the right.

End of Section One

See next page

Section Two: Short answer**35% (70 marks)**

This section has **10** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 26**(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any:

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(Note: No chemical equations necessary).

- (a) Some hydrochloric acid solution is mixed with solid sodium carbonate. (2 marks)

- (b) Some solid copper (II) hydroxide is mixed with a dilute nitric acid solution. (2 marks)

Question 27**(6 Marks)**

The uptake of carbon dioxide from the atmosphere by the oceans is leading to gradual acidification of the oceans (i.e. the oceans are becoming more acidic). When carbon dioxide dissolves, it reacts with water to form carbonic acid, which in turn forms hydrogen carbonate and then carbonate ions.

- (a) Write balanced chemical equations showing carbon dioxide reacting with water to form carbonic acid, and then the two successive ionisation reactions that carbonic acid undergo in water. (3 marks)

(i) _____

(ii) _____

(iii) _____

One of the most significant consequences of ocean acidification is the effect that it has on shellfish and other marine life that produce calcium carbonate and relies on it as a major component of the exoskeleton or other supporting structure. If the water is sufficiently acidic, the carbonate structures may not form completely. Ocean acidification is thought to lead to a reduction in the availability of carbonate ions. Further reaction of the dissolved carbon dioxide occurs as shown below.



- (b) Identify a conjugate acid-base pair in this reaction, and explain why it is classified as a Brønsted – Lowry acid-base reaction. (3 marks)

Question 28**(6 Marks)**

The Brønsted – Lowry theory can be used to account for the acidic and basic properties of a much wider array of substances whose properties cannot be easily explained using earlier theories.

Complete the following table by stating the pH, and give a supporting balanced chemical equation to explain the pH for each of the substances listed.

(6 marks)

Substance	pH (acidic, basic or neutral)	Equation
$\text{Mg}(\text{CH}_3\text{COO})_2 (\text{aq})$		
$\text{NH}_4\text{Cl} (\text{aq})$		
$\text{NaHSO}_4 (\text{aq})$		

Question 29**(7 marks)**

Phosphate buffered saline (PBS) is a solution which is commonly used in biological research. It was specifically designed so that the ion concentrations of the buffer solution match those found in the human body. The table below gives a standard 'recipe' for making PBS. The four salts are dissolved in water to produce the concentrations indicated.

	Final concentration when dissolved in distilled water	
Salt	Conc. (g L^{-1})	Conc. (mmol L^{-1})
NaCl	8.0	137
KCl	0.2	2.7
Na_2HPO_4	1.42	10
KH_2PO_4	0.24	1.8

- (a) Which salt components would produce the buffering effect observed in PBS? Explain your answer. **(2 marks)**

- (b) Write an equation showing the buffering system that would form. (1 mark)

- (c) Explain how this buffer is able to resist a change in pH when a small amount of NaOH(aq) is added. (3 marks)

PBS is specially designed for use in molecular biology and microbiology labs, so it is made to particular specifications.

- (d) Describe one way you could increase the buffering capacity of PBS if you did not have to take into account its biological uses. (1 marks)

Question 30**(6 Marks)**

Bromine water, which is a dilute aqueous solution of bromine in water, is slightly acidic because of its reaction with water, represented by the following equation:



In aqueous solution, bromine, $\text{Br}_2(\text{aq})$ is brown. Hypobromous acid, $\text{HBrO}(\text{aq})$, and bromide ions, $\text{Br}^-(\text{aq})$ are both colourless.

State and explain using **collision theory** the colour changes that would be observed, if the following changes are made to the system at equilibrium.

- (a) Addition of $\text{NaOH}(\text{aq})$.

(3 marks)

Colour:

Explanation:

- (b) Addition of excess $\text{HCl}(\text{aq})$.

(3 marks)

Colour:

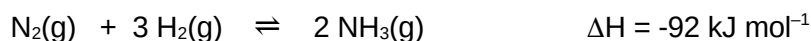
Explanation:

Question 31**(5 marks)**

Calculate the pH of the resultant solution, if 25.0 mL of 2.00 mol L⁻¹ sodium hydroxide and 52.0 mL of 1.00 mol L⁻¹ hydrochloric acid are mixed together. (5 marks)

Question 32**(9 Marks)**

The manufacture of ammonia on an industrial scale is carried out using the Haber process, which relies on the reversible reaction of nitrogen and hydrogen in the presence of an iron catalyst, as shown in the following equation:



The conditions for the reaction in industry must be chosen carefully, taking into consideration not only the yield, but also the rate of the reaction. Commonly, a temperature of around 500°C is used, and the reaction operated at a pressure of around 20,000 kPa. Since ammonia has a much higher boiling point than the other gases, it can easily be removed from the equilibrium mixture by condensation.

- (a) In the space provided below, draw a fully labelled enthalpy level diagram for the Haber process, showing ΔH , E_A , **catalysed** and **uncatalysed** reaction pathways, and **axes with correct units** stated.

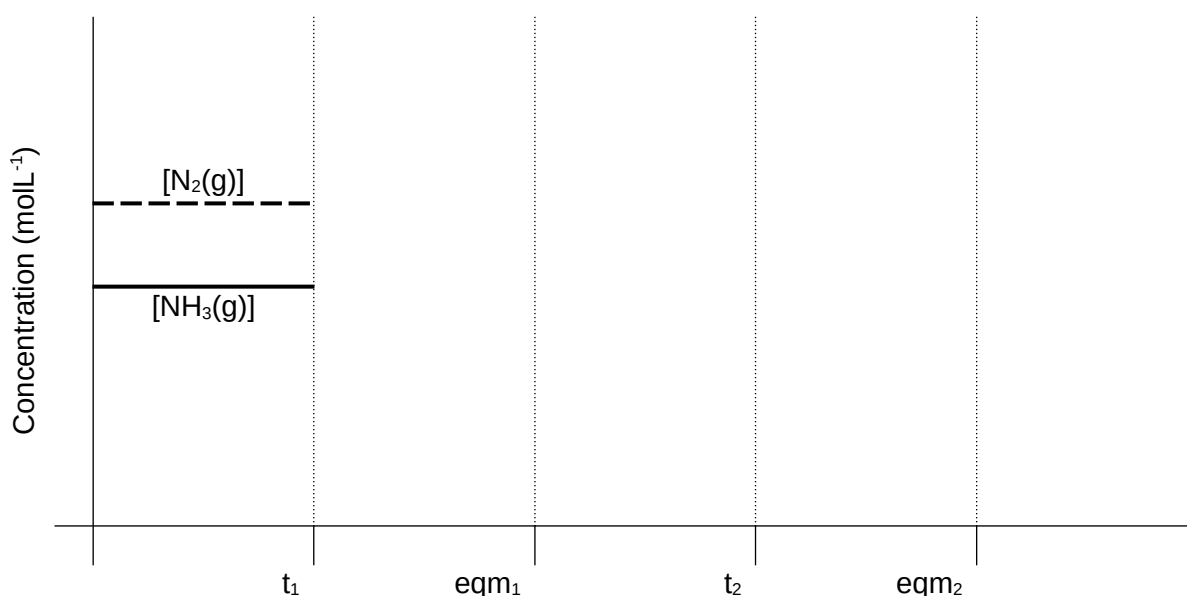
(5 marks)

A sealed vessel containing an equilibrium mixture of nitrogen, hydrogen and ammonia was subjected to the following changes in conditions:

- At a time, t_1 , the temperature of the vessel was increased
- At a time, eqm_1 , the system had returned to equilibrium
- At a time, t_2 , all ammonia was removed from the system
- At a time, eqm_2 , the system had again returned to equilibrium

(b) Complete the following graph, to show what happens to the concentrations of nitrogen and ammonia as the above changes are made.

(4 marks)



Question 33

(10 Marks)

Aluminium salts are acidic due to the presence of the hexaaqualuminate ion, $[Al(H_2O)_6]^{3+}$ which is formed when a soluble aluminium salt is dissolved in water. This ion undergoes hydrolysis as follows:



(a) Write the equilibrium constant (K) expression for this reaction.

(1 mark)

--

(b) A solution of aluminium nitrate has a pH of 5.6.

- (i) Using the above equilibrium reaction, explain how the pH of the solution would change, if more crystals of hydrated aluminium nitrate were dissolved into the solution.

(3 marks)

- (ii) When a small volume of dilute sodium hydroxide was added to a sample of the original solution, the pH initially increased from 5.6 to 6.0, and then decreased back to 5.8. Explain these observations.

(3 marks)

- (c) It was found that when the aluminium nitrate solution was warmed, the pH of the solution decreased. From this information, deduce whether the forward reaction in the above equilibrium is endothermic or exothermic. Explain your reasoning.

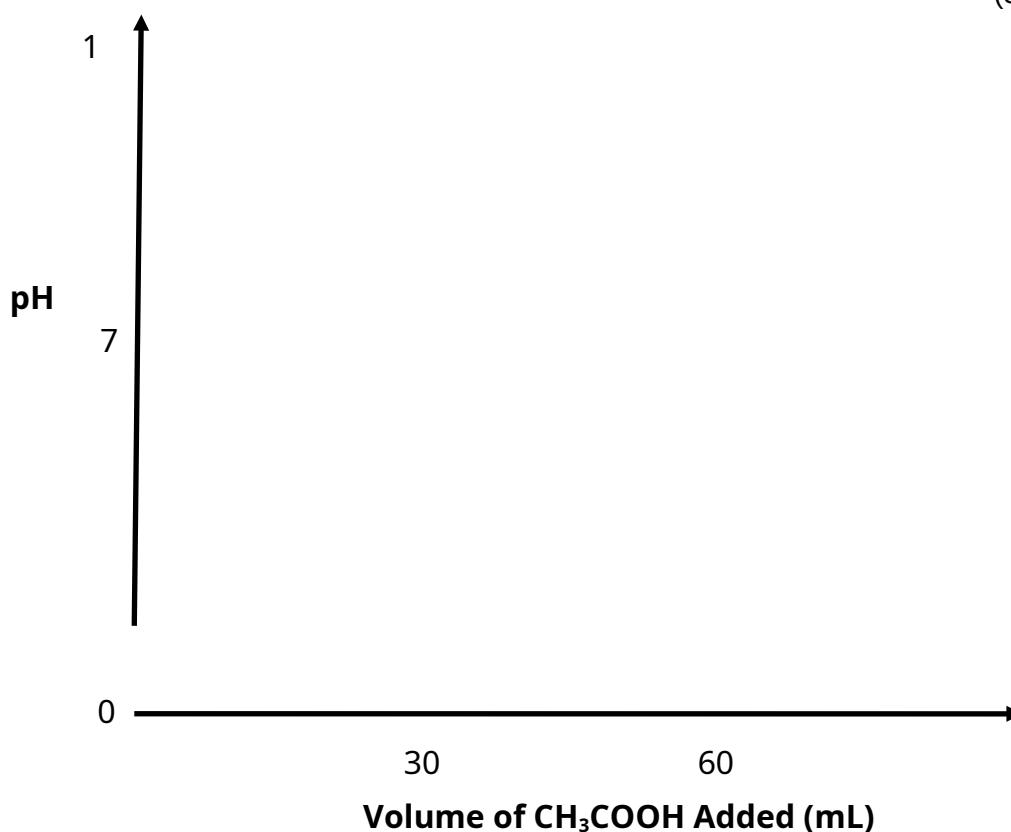
(3 marks)

Question 34**(8 Marks)**

Ethanoic acid is a weak, **monoprotic** acid. In an experiment, a solution of approximately 0.2 mol L^{-1} ethanoic acid (CH_3COOH) is titrated with a standard solution of 0.200 mol L^{-1} sodium hydroxide in order to determine the accurate concentration of the acid. 30.00 mL of the sodium hydroxide solution was pipetted into a conical flask, and the ethanoic acid added from the burette.

- (a) Write a balanced **molecular** equation, including state symbols, for the reaction occurring. (2 marks)

- (b) On the axis below, sketch a graph showing how the pH would be expected to change during the titration, until an excess of the acid was added. (3 marks)



- (c) On the graph above, label the equivalence point for this reaction. (1 mark)
- (d) What should the pipette be rinsed with, **immediately** prior to use? (1 mark)

- (e) From the list below, circle the correct indicator, that would be suitable for use in this particular titration. (1 mark)

Methyl orange
(pH 3.1 – 4.4)

Phenolphthalein
(pH 8.3 – 10.0)

Bromothymol blue
(pH 6.0 – 7.6)

Question 35

(9 marks)

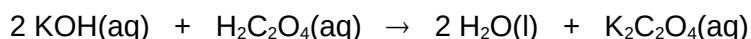
Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) is an organic acid, found in high levels in foods such as almonds, banana, rhubarb and spinach. It is a weak, diprotic acid, which has many uses in the laboratory, such as in volumetric analysis where it can be used as a primary standard.

- (a) Explain what is meant when oxalic acid is referred to as a 'weak, diprotic acid'. Use relevant chemical equations to support your answer. (4 marks)

Some oxalic acid dihydrate crystals were used to produce a primary standard for use in a titration. 4.434 g of $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}(\text{s})$ was dissolved in water and made up to 250.0 mL in a volumetric flask.

- (b) Calculate the concentration of the oxalic acid primary standard. (2 marks)

The oxalic acid solution was then used to standardise some aqueous potassium hydroxide. A 20.00 mL sample of $\text{KOH}(\text{aq})$ required 17.85 mL of oxalic acid to reach equivalence. The relevant chemical equation for the titration is shown below.



- (c) Calculate the concentration of $\text{KOH}(\text{aq})$. (3 marks)

End of Section Two**Section Three: Extended answer****40% (80 marks)**

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 36**(13 marks)**

Rising carbon dioxide levels in the atmosphere are believed to play an important role in the life of organisms known as calcifiers, a group that includes many forms of coral and crustaceans. These organisms use a precipitation reaction between calcium ions and carbonate ions present in sea-water to form shells and skeletons.

Measurements have detected a fall of around 0.1 in the pH of the oceans since the beginning of the industrial revolution at the end of the 18th century. Scientists believe this acidification can be attributed to an increase in the partial pressure of carbon dioxide in the atmosphere over the same period.

A student wished to investigate the composition of prawn shells. In order to do this, the student carried out a series of reactions to convert all the carbonate in the shells, (present as CaCO_3), to a soluble form, (i.e. CO_3^{2-}).

The steps that the student carried out were as follows:

- The shells of 10 prawns were ground to a fine powder using a mortar and pestle.
- 2.17 g of the powder was placed in a beaker, where it was chemically treated to convert all the carbonate into a soluble form.
- The resulting mixture was then filtered to remove any insoluble substances and the filtrate transferred to a 250 mL volumetric flask and made up to the mark with distilled water.
- 20 mL aliquots of the solution in the volumetric flask were titrated against a standard solution of nitric acid with a concentration of $0.0502 \text{ mol L}^{-1}$.
- All burette readings were taken from the **top of the meniscus**.
- The average titre of nitric acid used was 35.05 mL.

(a) Write a balanced ionic equation for the titration reaction. (2 marks)

(b) Calculate the number of moles of nitric acid titrated from the burette. (1 mark)

(c) Calculate the number of moles of carbonate in the 20.0 mL aliquots. (2 marks)

(d) Calculate the number of moles of carbonate in the original 2.17 g of powdered prawn shells, and thus calculate the percentage by mass of calcium carbonate in the sample of prawn shells. (5 marks)

- (e) State and explain what effect the student's decision to read the burette from the top of the meniscus would have had on the calculated percentage by mass. (3 marks)

**Effect on calculated
percentage (circle one)**

Artificially high

No effect

Artificially low

Explanation

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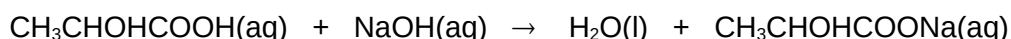
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Question 37**(14 marks)**

In the process of cheese making a bacterial culture is added to milk, which causes the milk to separate into the curds (solid cheese) and whey (remaining liquid). During this process the bacteria convert the lactose present in milk, into lactic acid, $\text{CH}_3\text{CHOHCOOH}$. Lactic acid is a weak, monoprotic, organic acid. Cheese makers use the concentration of lactic acid in the whey to determine when the reaction has proceeded to the extent that the cheese (curds) are ready for consumption or storage.

The concentration of lactic acid present in the whey can be determined at any time during the cheese making process via a simple titration. This usually involves taking a 10 mL sample of whey and titrating it against some standard sodium hydroxide solution, NaOH(aq) , using phenolphthalein as an indicator.

The reaction that took place in the titration is shown below.



- (a) Explain why phenolphthalein indicator is used. Use a chemical equation to support your answer. (3 marks)

A cheese maker added 4.00 L of milk to a small sample of bacterial culture. He knew that once the concentration of lactic acid reached $1.25 \times 10^{-2} \text{ mol L}^{-1}$ the cheese would be ready. He took a 10.00 mL sample of the whey, added several drops of phenolphthalein, and titrated the sample against a $0.111 \text{ mol L}^{-1} \text{ NaOH}$ solution. 1.15 mL of NaOH was required for equivalence.

- (b) Determine the concentration of lactic acid in the whey, and comment on whether or not the cheese maker should allow the reaction to proceed for longer before isolating the curds. (4 marks)

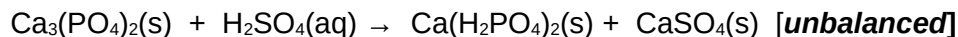
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- (c) Determine the percent by mass of lactic acid present in the whey at this point in time, if the 10.00 mL sample was taken from a total volume of 3.10 L of whey. The density (mass/volume) of the whey is 1.040 kg L^{-1} . (5 marks)

- (d) The cheese maker only took one 10.00 mL sample of whey to examine, Explain how he could improve the accuracy of his calculated lactic acid concentration. (2 marks)

Question 38**(10 marks)**

The fertiliser superphosphate, calcium dihydrogen phosphate ($\text{Ca}(\text{H}_2\text{PO}_4)_2$), was mined for many years on the Pacific island of Nauru. Phosphorus is an essential macronutrient to animals and plants. The fertiliser is now manufactured industrially by reacting sulfuric acid (H_2SO_4) with calcium phosphate "rock phosphate", ($\text{Ca}_3(\text{PO}_4)_2$).



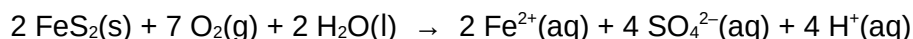
- (a) Write a balanced chemical equation for this process. (1 mark)
-

In a given day a reactor combines 35 000 kg of impure rock phosphate (75.0% purity, by mass) with 15 000 L of 18.0 M H_2SO_4 .

- (b) Determine which reactant is the limiting reagent. (5 marks)
- (c) Determine the mass of excess reactant remaining after the reaction. (2 marks)
- (d) What mass of superphosphate (in kg) would be produced, if the conversion process is 80.0 % efficient? (2 marks)

Question 39**(14 marks)**

When soils containing iron pyrite (FeS_2) are exposed to air, the following reaction occurs.



These types of soils are called acid sulfate soils. The pH of groundwater in these soils will decrease. If this groundwater discharges into lakes and rivers it will also cause their pH to decrease.

- (a) Explain how this reaction causes the pH of groundwater to decrease.

A titration was carried out on a sample of lake water, suspected of being contaminated with acid soils, to determine its pH.

A student placed a standardised solution of 0.005 mol L^{-1} NaOH in the burette. The student then titrated the NaOH solution against 50.0 mL samples of the lake water and obtained the following results.

	Trial 1	Trial 2	Trial 3	Trial 4
Final burette reading (mL)	4.25	8.05	12.00	16.05
Initial burette reading (mL)	0.00	4.10	8.10	12.05
Volume of NaOH used (mL)				

- (b) Determine the average volume of NaOH used. (2 marks)

- (c) Calculate the average number of moles of NaOH used to neutralise the acid. (1 mark)

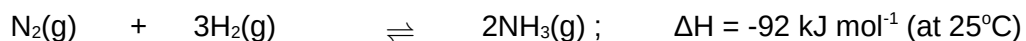
- (d) Assuming that the lake water is the only source of H^+ ions and that complete ionisation of the acid in the lake water has occurred, determine the pH of the lake water. (3 marks)

- (e) Complete the following table (6 marks)

Equipment	What is it used for in this experiment?	What should it be rinsed with before use?
Burette		
Pipette		
Conical flask		

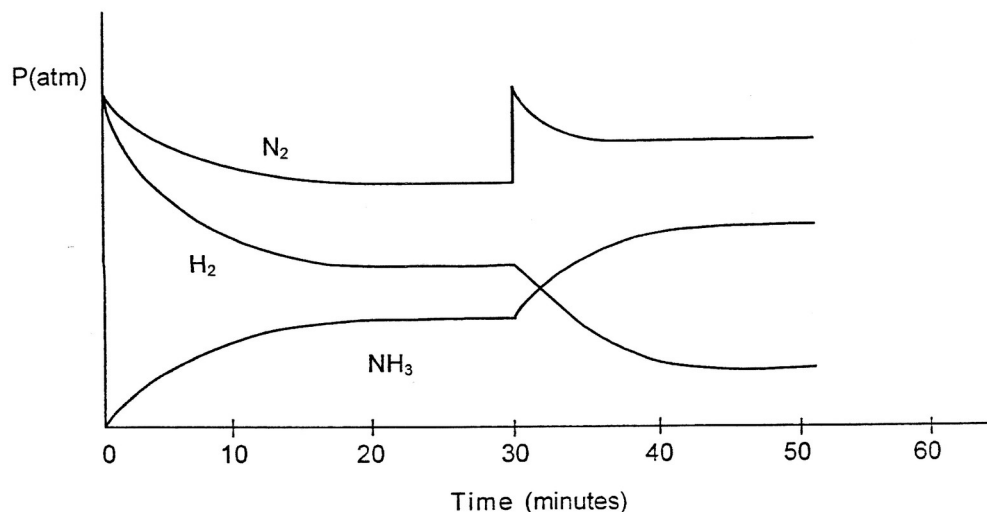
Question 40**(16 marks)**

Ammonia is an industrially important gas produced by the Haber process, as illustrated by the reaction below:



The reaction is catalysed by iron(III) oxide.

The following graph shows the partial pressures (gas concentrations) of the three species involved in the reaction.



Answer the following questions about the above graph.

(a) Why does the concentration of H_2 decrease more rapidly than that of the N_2 ? (1 mark)

(b) Why do the concentrations of each of the three species stabilise between 20 and 30 minutes? (1 mark)

(c) What has occurred at the 30-minute mark to cause the changes shown in the graph?

(1 mark)

(d) By the 40-minute mark, what difference will the change imposed at the 30-minute mark have made to the rate of:

(2 mark)

the forward reaction? _____

the reverse reaction? _____

(e) Using the collision theory, explain why the rate of forward reaction is affected by the imposed change at the 30-minute mark.

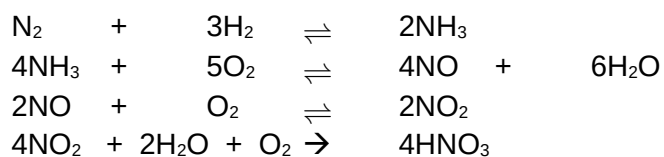
(3 marks)

(f) In the Haber process, at 200 atm pressure the yield of ammonia doubles if the temperature is dropped from 500°C to 400°C. Why do the manufacturers continue to use higher temperatures?

(2 marks)

- (g) Likewise, if the temperature is kept the same and the pressure inside the reaction vessel is tripled, the yield doubles. Why do the manufacturers continue to use lower pressures? (2 marks)

Ammonia is used as an intermediate in a number of industrial processes. One such process is the manufacture of nitric acid. The sequence of reactions in the manufacture of nitric acid are:



- (h) Determine the mass of nitrogen and its volume at STP, required to produce 5.0 Kg of pure nitric acid. (3 marks)

Question 41**(14 marks)**

A damp mixture of potassium iodide and potassium sulfate was dissolved in water and made up to 250.00 mL. 25.00 mL of this solution was treated with excess barium nitrate until no further precipitate formed. The solid was filtered and washed. It was then dried to a constant weight of 0.218 g.

A second 25.00 mL sample of the solution was treated with excess of lead nitrate solution until no further precipitate formed. The solid mixture of precipitates was filtered and washed. It was then dried to a constant weight of 0.607 g.

- (a) Write the ionic equation for the precipitation reaction that occurred in step one.
(2 marks)

- (b) Write the TWO ionic equations for the precipitation reactions that occurred in step two.
(4 marks)

- (c) Calculate the masses of potassium iodide and potassium sulfate in the original sample.
(8 marks)

End of Questions

See next page
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Question number: _____

[illegible]

Question number: _____

[illegible]

Question number: _____

[illegible]

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