

Year 12 Semester Two Examination, 2009

Question/Answer Booklet

CHEMISTRY

Student Name/Number:	
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Part	Mark
1	/60
2	/70
3	/50
4	/20
Total	/200
%	

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Paper
Separate Multiple Choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate

Standard Items: Pens, pencils, eraser or correction fluid, ruler, highlighter
Special Items: A blue or black pen or a B or 2B or HB pencil for the separate Multiple Choice Answer Sheet and Calculators satisfying the conditions set by the Curriculum Council for this subject.

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

Part	Number of questions available	Number of questions to be attempted	Suggested working time (minutes)	Marks available
1 Multiple-Choice	30	30	55	60
2 Short Answers	10	10	60	70
3 Calculations	5	5	45	50
4 Extended Answers	1	1	20	20
Total marks				200

Instructions to candidates

1. Answer the questions according to the following instructions:

Part 1

Answer **all** questions on the separate Multiple-Choice Answer Sheet. Use a blue or black pen 2B or B pencil.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers.

Parts 2, 3 and 4

Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point or ink pen should be used.

Questions containing specific instructions to show working should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

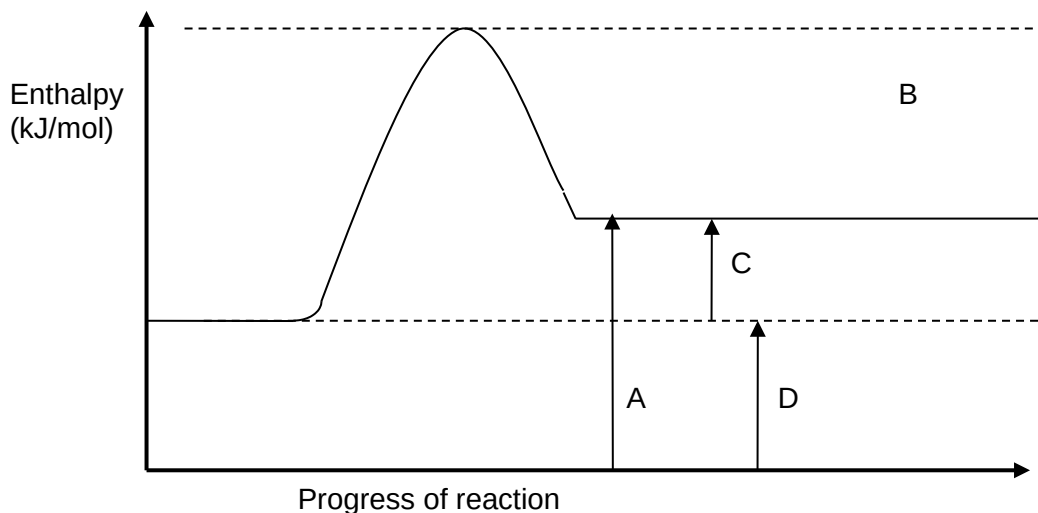
2. It is recommended that you spend your reading time mainly reading the Instructions to candidates and Parts 2, 3 and 4.
3. At the end of the examination make sure that your name is on your Question/Answer Booklet and on your separate Multiple-Choice Answer Sheet.
4. **Chemical Equations**
For full marks, chemical equations should refer only to those specific species consumed in the reaction and the new species produced. These species may be **ions** [for example Ag^+ (aq)], **molecules** [for example $\text{NH}_3(\text{g})$, $\text{CH}_3\text{COOH}(\ell)$, $\text{CH}_3\text{COOH}(\text{aq})$] or **solids** [for example $\text{BaSO}_4(\text{s})$, $\text{Cu}(\text{s})$, $\text{Na}_2\text{CO}_3(\text{s})$].

PART 1 (60 marks)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a blue or black pen or a 2B or B pencil. Each question in this part is worth 2 marks.

1. Which one of the following correctly represents the distribution of the electrons in the chloride ion?
 - (a) $1s^2 2s^2 2p^6 3s^2 3p^5$
 - (b) $1s^2 2s^2 2p^6 3s^2 3p^6$
 - (c) $1s^2 2s^2 2p^6 3s^2 3p^5 4s^2 4p^5$
 - (d) $1s^2 2s^2 2p^6 3s^2 3p^5 4s^2 4p^6$
2. Which one of the following is an exothermic process?
 - (a) $\text{Ba}(g) \rightarrow \text{Ba}^+(g) + e^-$
 - (b) $2\text{SO}_3(g) \rightleftharpoons \text{SO}_2(g) + \text{O}_2(g)$
 - (c) $2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)$
 - (d) Chemical bond breaking.
3. An element has the following successive ionisation energies in kJ mol^{-1} : 1950, 2730, 4550, 6020, 12 300, 15 400, 18 900. In which group of the Periodic Table is this element most likely to be found?
 - (a) Group II
 - (b) Group III
 - (c) Group IV
 - (d) Group V
4. Which of the following substances would **not** react with acidified potassium permanganate solution?
 - (a) hexanoic acid
 - (b) ethanol
 - (c) butanal
 - (d) 2-propanol

The next **two** questions relate to the following energy profile diagram.



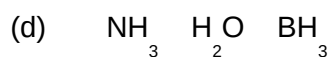
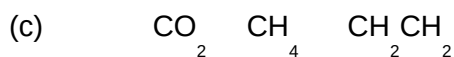
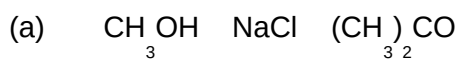
5. Which of the following statements is **true**?
- A catalyst for this reaction would decrease the size of C.
 - The activation energy for the forward reaction is represented by A.
 - The chemical process is exothermic.
 - The activation energy for the reverse reaction is represented by B.
6. The enthalpy change for the **forward** reaction is represented by:
- A - D
 - A
 - C + D
 - B + C
7. What is the equilibrium constant expression for the following heterogeneous reaction?
- $$\text{Ce}_2\text{SO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightleftharpoons 2\text{Cs}^+(\text{aq}) + \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$$
- $K = [\text{Cs}^+]^2 [\text{H}_2\text{O}] [\text{SO}_2]$
 - $K = \frac{[\text{Cs}^+]^2 [\text{SO}_2] [\text{H}_2\text{O}]}{[\text{Cs}_2\text{SO}_3] [\text{H}^+]^2}$
 - $K = \frac{[\text{Cs}^+]^2 [\text{SO}_2]}{[\text{H}^+]^2}$
 - $K = \frac{[\text{H}^+]^2}{[\text{Cs}^+]^2 [\text{SO}_2]}$

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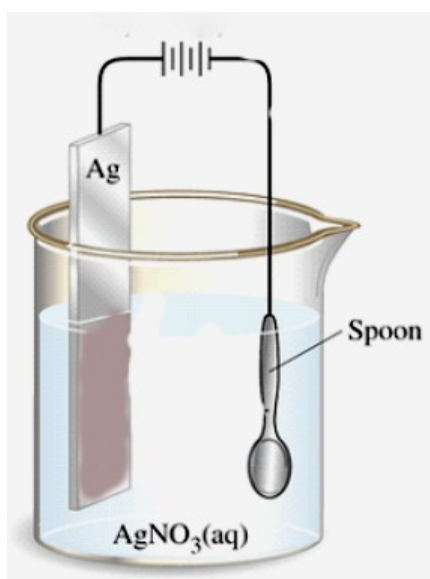
8. How many structural isomers are possible with the molecular formula C_4H_8 ?

- (a) 3
- (b) 4
- (c) 5
- (d) 6

9. Which of the following sets contain only polar molecules?



10. A student decided to silver-plate a spoon using the apparatus shown.



In this cell, the spoon is the:

- (a) anode and is connected to the positive terminal of the power supply.
- (b) anode and is connected to the negative terminal of the power supply.
- (c) cathode and is connected to the positive terminal of the power supply.
- (d) cathode and is connected to the negative terminal of the power supply.

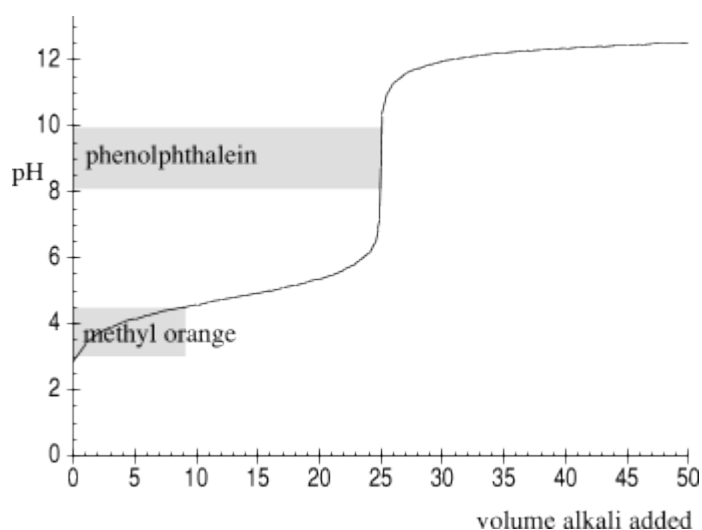
11. Which of the following substances exhibits both ionic and covalent bonding?

- (a) $\text{SiO}_2(\text{s})$
- (b) $\text{Au}(\text{CN})_2^- (\text{aq})$
- (c) $\text{CH}_3\text{CH}_2\text{COOCH}_3 (\text{l})$
- (d) $\text{HNO}_3(\text{g})$

12. Which one of the following molecules has six bonding electrons?

- (a) CO
- (b) HCHO
- (c) C_2H_4
- (d) SO_3

13. Consider the following titration curve.



Which of the following statements is **incorrect**?

- (a) The methyl orange acid-base indicator would change colour before the equivalence point.
- (b) The graph represents the titration of weak acid with a strong base.
- (c) The pH at the equivalence point is 7 (neutral).
- (d) If phenolphthalein indicator is used, the solution will change from colourless to pink at the endpoint.

14. There are many methods used to extract metals from ores and salts, including carbon reduction, electrolysis, and displacement.

Which of the following methods is the most suitable for the extraction of calcium metal?

- (a) electrolysing molten calcium chloride
 - (b) reducing calcium oxide with carbon
 - (c) reducing calcium chloride with aluminium
 - (d) electrolysing an aqueous solution of calcium chloride
15. As a lead acid accumulator (secondary cell) is discharging, the pH of the electrolyte solution will:
- (a) decreases steadily
 - (b) remains constant
 - (c) increases steadily
 - (d) decreases rapidly before becoming constant
16. The propellant used in the solid rocket booster of the space shuttle is a mixture of aluminium and another compound. This substance contains chlorine, which has an oxidation number of +7 in this compound.

Which of the following substances could it be?

- (a) HOCl
 - (b) NH_4Cl
 - (c) NH_4ClO_4
 - (d) NH_4ClO_3
17. The soft drink, Coca-cola, contains phosphoric acid, and has a pH of 2.8.

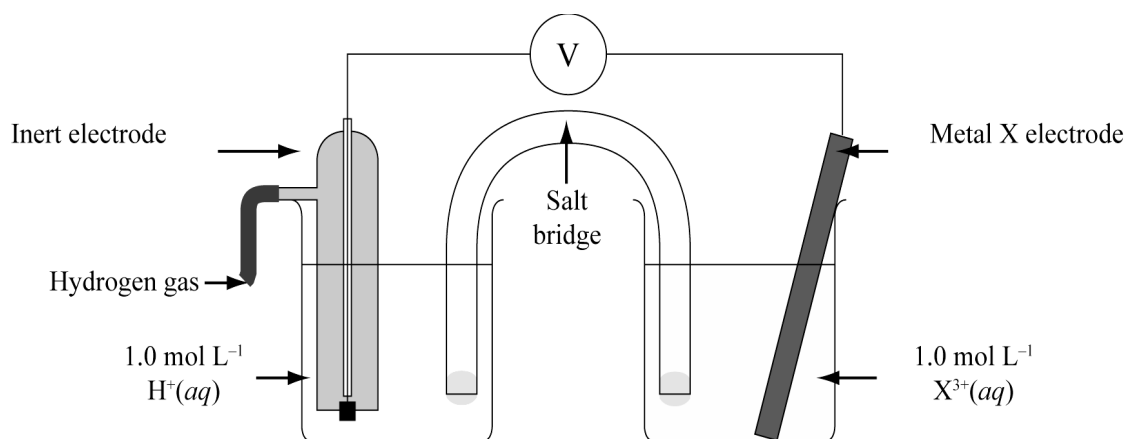
Which of the following statements is **true**?

- (a) Phosphoric acid is a strong triprotic acid.
- (b) The concentration of OH^- ions in Coca-cola is very low.
- (c) When carbon dioxide gas is bubbled through Coca-cola its pH will rise.
- (d) Phosphoric acid is a very strong electrolyte.

18. In comparing potassium and calcium with the transition metals in period 4 of the periodic table, transition metals tend to:
- (a) be harder and have higher electronegativities.
 - (b) have lower melting temperatures and form coloured complexes.
 - (c) be more easily oxidised and display variable oxidation states.
 - (d) have lower ionisation energies and be magnetic.

Consider the following diagram for the next **two** questions.

The cell setup below is run for several minutes.



19. If X is the element gold, which one of the following statements is **false**?
- (a) Under standard conditions, the cell E° (e.m.f) would be +1.50 V.
 - (b) Anions and cations will migrate through the salt bridge.
 - (c) Hydrogen gas molecules will be reduced.
 - (d) The cathode will increase in mass.
20. If Fe (iron) is metal X and the gas electrode half cell is changed to a $\text{Cl}_2(\text{g})/\text{Cl}^-(\text{aq})$ half cell then it is **true** to say that:
- (a) the iron electrode will increase in mass.
 - (b) Cl_2 will be oxidized to Cl^- and Fe will be reduced to Fe^{2+} .
 - (c) anions will move from the right half cell to the left half cell.
 - (d) the cell E° (e.m.f) would be higher than the previous cell, under standard conditions.

See next page

21. For a closed gaseous system: $2\text{NOCl}(g) \rightleftharpoons 2\text{NO}(g) + \text{Cl}_2(g)$

Which one of the following statements is **true**, given that the system is at equilibrium?

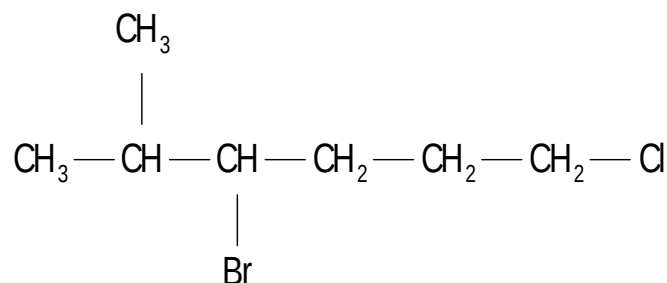
- (a) The rate of the forward reaction is less than the rate of the reverse reaction.
 - (b) The concentrations of NOCl and NO must be equal.
 - (c) The addition of He(g), at constant volume, leads to the formation of more NOCl, as a new equilibrium is established
 - (d) The removal of NO from the system will decrease the overall reaction rate.
22. Which one of the following compounds, when dissolved in water, would **not** give an acidic solution?
- (a) FeCl_3
 - (b) KI
 - (c) HCN
 - (d) SO_3
23. Pig iron which is obtained directly from a blast furnace has limited industrial value because:
- (a) it is too brittle.
 - (b) it is too soft.
 - (c) it contains too many impurities.
 - (d) its melting point is too low.
24. The “key” step in the Contact Process is:



Which of the following conditions achieves the highest reaction rate, and highest reaction yield?

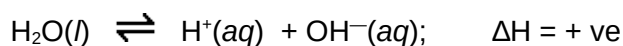
- (a) low temperature; high pressure.
- (b) high temperature; pressure higher than atmospheric pressure.
- (c) low temperature; pressure lower than atmospheric pressure
- (d) high temperature; low pressure.

25. The corrosion of iron on the roof top of a house may most accurately be described as:
- (a) the spontaneous oxidation of an active metal.
 - (b) the reduction of the metal surface by the components and pollutants of the environment.
 - (c) a process by which $\text{Fe}(\text{OH})_2$ is converted to $\text{Fe}(\text{OH})_3$.
 - (d) a process in which iron metal becomes the positive electrode of a galvanic cell.
26. Consider the following reaction and determine which of the conditions indicated will change the value of the equilibrium constant?
- $$4 \text{NH}_3(\text{g}) + 5 \text{O}_2(\text{g}) \rightleftharpoons 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g}); \Delta H = -\text{ve}$$
- (a) Decrease pressure.
 - (b) Add an iron/iron oxide catalyst.
 - (c) Remove ammonia gas.
 - (d) Increase temperature.
27. The best IUPAC name for the structure below is:



- (a) 1-chloro-4-bromo-5-methylhexane
- (b) 4-bromo-1-chloro-5-methylhexane
- (c) 3-bromo-6-chloro-2-methylhexane
- (d) 3-bromo-6-chloroheptane

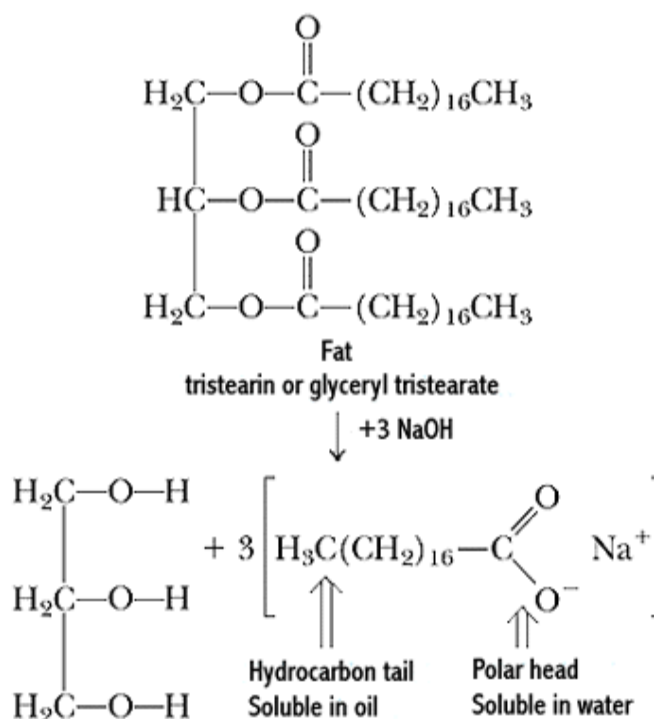
28. Pure water ionizes to a small degree according to the equilibrium:



The pH of water in a small rock pool was measured on a cold morning (5°C) to be 7.2. In the afternoon the temperature of the water had risen to 25°C.

What would be the pH of the water in the afternoon (assuming no other influences)?

- (a) Much lower than 7.2
 (b) Equal to 7.2
 (c) Slightly greater than 7.2
 (d) Less than 7.2
29. The diagram represents the making of soap.



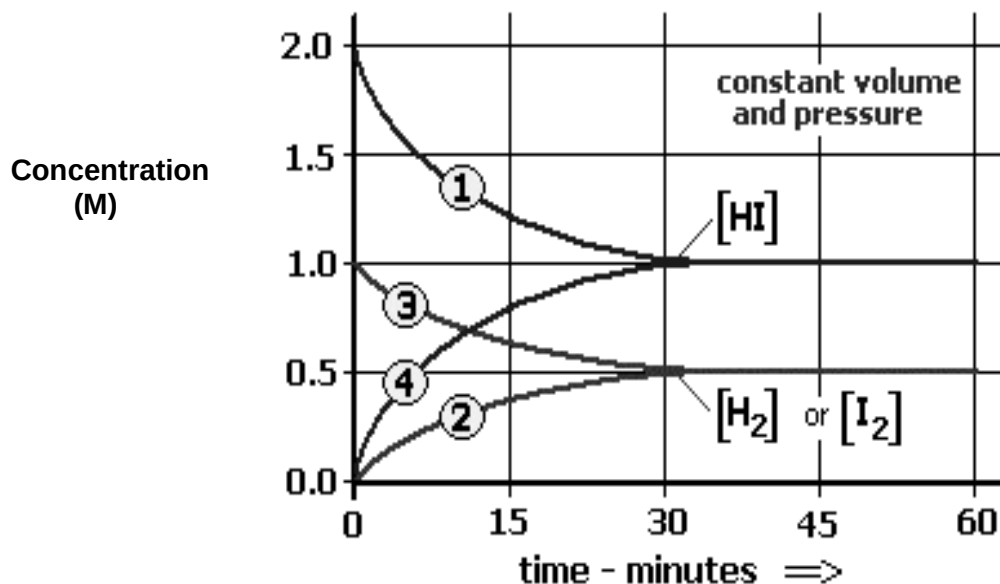
Which one of the following options is correct?

	Product 1	Product 2	Chemical process
(a)	glycerol	sodium stearate	esterification
(b)	glycerol	stearic acid	hydrolysis
(c)	1,2,3-propanetriol	sodium stearate	saponification
(d)	1,2,3-propanetriol	sodium glycerate	ionisation

30. Consider the gaseous system: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

After 30 minutes the system had reached equilibrium.

From the changes in concentrations over this time it is possible to identify each species.



Which one of the following combinations identifies each of the three species correctly?

	$\text{H}_2(\text{g})$	$\text{I}_2(\text{g})$	$\text{HI}(\text{g})$
(a)	③	②	①
(b)	③	③	②
(c)	②	②	①
(d)	②	②	④

End of Part 1

See next page

PART 2 (70 marks)

Answer ALL questions in Part 2 in the spaces provided.

1. Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs write "no reaction".

Following this, describe **in full** what you would observe in each case, 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.

- (a) Sodium phosphate solution is added to calcium chloride solution.

Equation _____

Observation _____

[3 marks]

- (b) Copper turnings are added to a concentrated nitric acid solution.

Equation _____

Observation _____

[3 marks]

- (c) Pentanol, ethanoic acid and concentrated sulfuric acid solutions are heated gently.

Equation _____

Observation _____

[3 marks]

- (d) Concentrated ammonia solution is added to solid zinc hydroxide.

Equation _____

Observation _____

[3 marks]

2. For the species listed in the table below, draw electron dot structures, representing **all** valence shell electron pairs as : or as –

Species	Structural formula
Perchlorate ion, OCl^-	
Hydrogen cyanide, HCN	
Lead (II) carbonate PbCO_3	

[6 marks]

3. The use of lead-based paints is now banned. Prior to this many works of art were created with paint that contained lead. Sulfur, which is one form of air pollution, reacted with the paint to produce a black solid called lead (II) sulfide. This resulted in the darkening of art gallery paintings over time.
A solution to the problem was to convert the lead (II) sulfide to white lead (II) sulfate, using the oxidant hydrogen peroxide, H_2O_2 .

By considering the redox half equations, write a balanced redox equation for the process.

[3 marks]

4. Many ionic substances exhibit acid-base properties through hydrolysis reactions. Show this with the following species:

Ion	Hydrolysis reaction	Acidic (A) or Basic (B) ion.
NH_4^+		
CO_3^{2-}		

[4 marks]

5. The lithium cell uses the anode reaction $\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$ which has a large oxidation potential. Lithium cells deliver current at a potential difference of 4 V. There is a variety of cathode reactions in commercial lithium cells, including the reduction of I_2 to I^- . The electrolyte of these cells is a lithium salt dissolved in a polar organic liquid, such as methoxymethane (CH_3OCH_3).

- (a) Write a balanced equation for the overall cell reaction.

[2 marks]

- (b) Why is water not a suitable polar liquid to be used in a lithium cell?

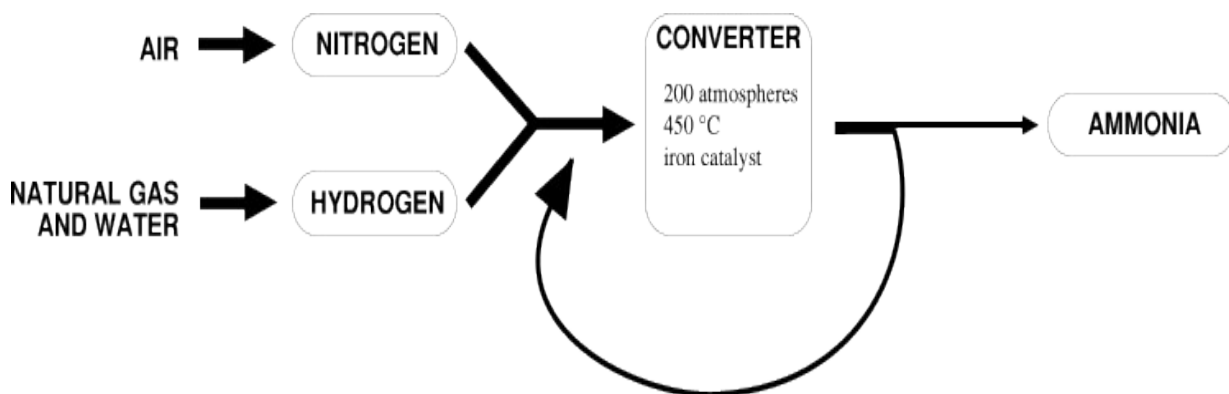
[1 mark]

6. Describe the nature and types of bonding in $\text{CH}_3\text{COOH}_{(\text{s})}$.

[3

marks]

7. The following flow chart represents the Haber process.



(a) Through what separation process is nitrogen gas obtained from air?

[1 mark]

(b) Give ONE example of an industrial use of ammonia.

[1 mark]

(c) In physical terms, how does the catalyst affect the chemical reaction?

[2 marks]

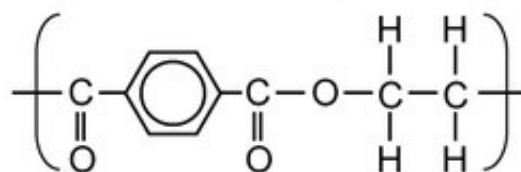
(d) Use "Collision theory" to briefly explain how ammonia forms.

[3 marks]

(e) How is the ammonia removed from the system?

[2 marks]

8. One of the most commonly recycled plastics is PET (polyethylene terephthalate). It is a copolymer, used to make drink bottles as it is strong, not brittle, and can withstand high CO_2 gas pressures.
The section of its polymeric structure is shown below:



The two different monomers in PET are called polyethylene glycol and terephthalic acid.

- (a) Draw the two monomer structures.

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[2 marks]

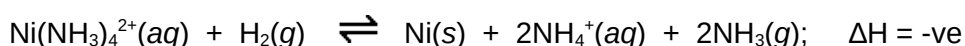
- (b) What type of polymerisation process is used to produce PET?

_____ [1 mark]

- (c) Why would the polymer not be brittle?

_____ [1 mark]

9. The following equilibrium reaction is a step in the production of nickel metal.



Complete the following table, giving your answers as “increases”, “decreases” or “no change”.

Change made to the equilibrium system	Effect on rate of the forward reaction	Effect on the equilibrium yield of Ni(s)
$\text{NH}_3(\text{g})$ is removed		
Temperature is decreased		
An appropriate catalyst is added		

[6 marks]

10. (a) Many older homes still have iron pipes carrying gas and water, and over time need repair. The “plumber’s dilemma” is that when repairing pipes they should never attach a copper pipe to an iron one. Explain.

[2 marks]

- (b) Oil rigs often have large blocks of aluminium attached to their superstructures. What is the reason for this?

[2 mark]

11. The Hall-Heroult cell is used to produce aluminium metal by electrolytic reduction of molten aluminium oxide. This is an electrowinning process.

- (a) Why is cryolite (Na_3AlF_6) added to the cell?

[1 mark]

- (b) The electrical current required is very high. Between 150-250 kA of electrical current is required for a 'potline' of typically 100-240 cells.

What fossil fuel is widely used to generate such large amounts of electrical energy?

[1 mark]

- (c) There are two greenhouse gases produced in large amounts in these cells. Both are carbon compounds, with one of them being produced by the decomposition of cryolite and the subsequent complete fluoridation of carbon.

Write the chemical formulas of these two gases.

[2 marks]

12. (a) Draw structural formulae for each of the following compounds.

Name	Structural (or semi structural) formula
3-bromo-2,3-dimethyl-1-pentanal	
cis-1,2-dichloropropene	

[4 marks]

- (b) A certain alcohol has the molecular formula, $C_5H_{12}O$, and does not decolourize acidified potassium permanganate.

Give the name AND structural (or semi structural) formula of an **alcohol** that fits this description.

Name:	Formula:

[2 marks]

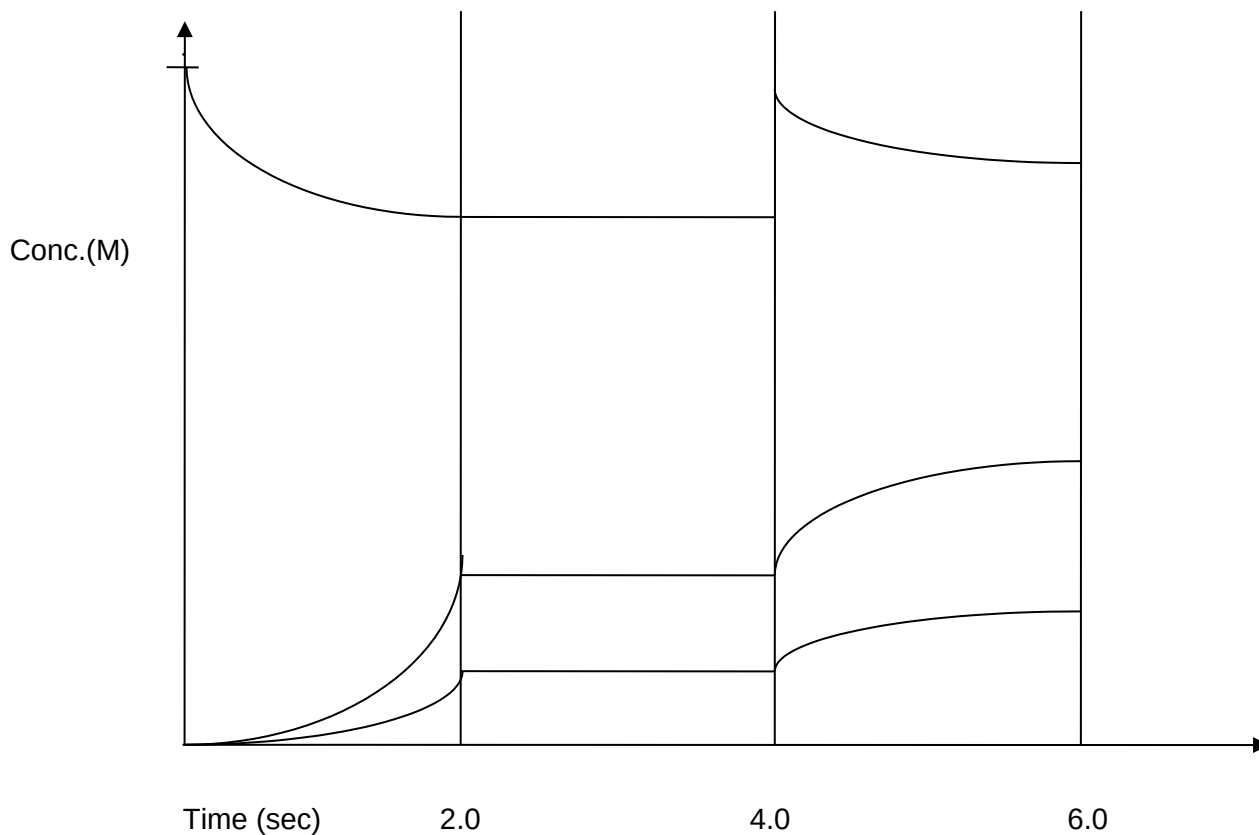
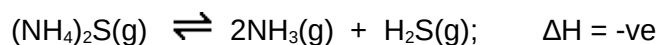
- (c) Name the products of the reaction of this alcohol with sodium metal.

Product 1 _____

Product 2 _____

[2 marks]

13. Ammonium sulfide gas is pumped into a reaction vessel of fixed volume and decomposes according to the following reaction equilibrium:



- (a) What has occurred at 2.0 seconds?

[1 mark]

- (b) What change has occurred to the system at 4.0 seconds?

[1 mark]

- (c) Indicate on the diagram above, changes that would occur if the temperature of the system was **increased** at 6.0 seconds.

[2 marks]

- (d) How would a catalyst affect the system between 0.0 and 2.0 seconds? Show this on the graph for **ammonia gas** only.

[1 mark]

End of Part 2

See next page

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PART 3 (50 marks)

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct answers and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b) and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning; if you don't, you will lose marks.

Question 1

(7 marks)

When solid ammonium sulfite $((\text{NH}_4)_2\text{SO}_3)$ is heated strongly it decomposes to form the gases ammonia (NH_3) , sulfur dioxide (SO_2) , and water.

A 1.54 g sample of ammonium sulfite decomposed at 302 °C in a sealed gas vessel of volume 1.850 L.

- Write a balanced chemical equation for the reaction.
- Calculate the pressure inside the gas vessel when decomposition is complete.
- The gaseous products are passed through limewater, $(\text{Ca}(\text{OH})_2(aq))$. What mass of calcium sulfite (CaSO_3) would precipitate?

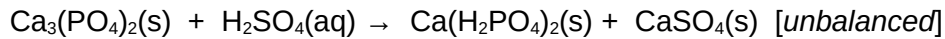
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[illegible]

Question 2

(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.

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 .

- Determine which reactant is the limiting reagent.
- Determine the mass of excess reactant remaining after the reaction.
- What mass of superphosphate (in kg) would be produced, if the conversion process is 80.0 % efficient?
- What is a use of the element phosphorus in animals?

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[illegible]

Chocolate is made from the seeds of a plant called *Theobroma cacao*. Chocolate contains many compounds, including the bitter alkaline substance, theobromine. It is found in the cacao plant and is a water insoluble, crystalline white solid.

The compound theobromine contains the elements carbon, hydrogen, nitrogen and oxygen.

The complete combustion of 3.22 g of the compound released 5.51 g of carbon dioxide and 1.28 g of water.

Further testing of 1.68 g of the compound converted all its nitrogen to NO_2 gas. This gas occupied a volume of 1.12 L, at 100°C and 103 kPa pressure.

- (a) Determine the empirical formula of theobromine.
- (b) Analysis of the compound indicates that its relative molecular mass is approx.180. Determine its molecular formula.
- (c) Theobromine is toxic to dogs. The toxicity level is 300 mg per kg of dog. How much chocolate would a 8.00 kg dog need to consume to poison itself if a particular brand of chocolate on offer contains 2.50 % (by mass) theobromine?

[illegible]

Question 4

(9 marks)

Heartburn, which is a symptom of indigestion, can be caused by elevated levels of acid in the stomach. One particular “antacid” from the pharmacy has the following information on its label:

Each 10.0 mL dose contains 350 mg of solid magnesium hydroxide and 300 mg of solid aluminium hydroxide, suspended in water.

This “antacid” mixture neutralises hydrochloric acid in the stomach. The stomach acid has a pH of 1.8.

- What is the hydrogen ion concentration, in mol L^{-1} , of the acid in the stomach?
- Write two balanced ionic equations to show the reactions between the acid and each of the magnesium hydroxide and aluminium hydroxide compounds.
- What is the volume of stomach acid which would be neutralised by 10.0 mL of the antacid suspension?
- Stomach acid also be neutralised by taking a “home remedy” of bicarbonate of soda (NaHCO_3), in water. What is a potential “problem” with this ‘home remedy’?

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[illegible]

Question 5

(13 marks)

The chromium plating of metals often requires that the metal surface is initially coated with nickel or copper, before it can be electroplated with chromium.

In the first stage (copper plating), a metal lamp off an old car was placed in an electrolytic bath containing 1.50 M copper sulfate. A constant electric current of 0.500 A was passed through the cell for a period of 250 minutes. The cell anode was made of pure copper.

- (a) What mass of copper would be plated onto the object?
- (b) What would be the loss of mass at the anode?
- (c) What would be the final concentration of the copper sulfate solution?

In the second stage (chromium plating), the copper plated lamp was washed and dried then placed in a different electrolytic bath containing dichromic acid ($\text{H}_2\text{Cr}_2\text{O}_7$).

The cathode reaction converts dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ions to chromium (Cr) metal.

- (d) Write a half equation for this reaction.

The concentration of dichromic acid was held constant by the continuous addition of chromium anhydride, CrO_3 to the cell bath, according to the equation:



A constant electric current of 2.04 A was applied to the cell and the metal lamp was coated with 5.45 g of chromium.

- (e) How much time would the cell need to run to achieve this?
- (f) What mass of CrO_3 must be added, in this time period, to maintain a constant dichromic acid solution concentration?

[illegible]

End of Part 3

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PART 4**(20 marks)**

Answer the following question. Marks are awarded principally for the relevant chemical content of your answer, and also for coherence and clarity of expression. **Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing.**

Your answer should be presented in about 1½ – 2 pages. Begin your essay on the lined paper following the end of the questions.

The quality of water varies from one location to another. A sufficient level of dissolved oxygen is essential for the survival and propagation of aquatic life forms e.g. fish require 5.0 ppm of dissolved oxygen to survive. One test of 'water health' is to determine the amount of dissolved oxygen, using a modified version of the Winkler Method.

Procedure / theory:

- Step 1 Using appropriate sampling techniques water samples are collected from a lake. The screw-topped water bottles are completely filled with the filtered water.
- Step 2 In the laboratory, fresh reagents, and equipment are prepared.

Equipment provided	Reagents to be prepared/used
4 x 300 mL screw-topped bottles	2.15M MnSO ₄ [2 mL required per sample]
Top loading balance/spatula	2M NaOH solution [2 mL per sample]
50 mL burette/retort stand/clamp	9M H ₂ SO ₄ [4 mL per sample]
5 mL graduated pipette	Starch indicator [2 mL per sample]
Thermometer	13.5% (by mass) sodium iodide solution [2 mL required per sample]
Measuring cylinder	
500 mL conical flasks	0.0365M standardised Na ₂ S ₂ O ₃ solution
20.0 mL pipette/suction bulb	Wash bottle [with deionised water]
Plastic gloves and safety glasses	Note: MnSO ₄ is a skin irritant, and Na ₂ S ₂ O ₃ is poisonous.
Funnel	
Miscellaneous glassware	

- Step 3 Manganese sulfate is carefully added to the water samples with sodium hydroxide to form manganese (II) hydroxide, Mn(OH)₂. The Mn(OH)₂ reacts with dissolved oxygen(O₂) and water to form the brown precipitate, Mn(OH)₃.
- Step 4 Sulfuric acid solution, then sodium iodide (I⁻) is added to the mixture. The Mn³⁺ ion reacts with iodide (I⁻) ions to form Mn²⁺ iodine (I₂).
- Step 5 A 20.00 mL aliquot of this mixture is transferred to a flask and starch indicator added. Starch reacts with the I₂ to form a deep blue coloured solution.
- Step 6 The resulting solution is titrated with a sodium thiosulfate solution (S₂O₃²⁻). This converts the iodine back into iodide ions, and the thiosulfate ions are converted to tetrathionate ions (S₄O₆²⁻). The solution is colourless at the endpoint.

From the information provided and your understanding of chemical principles and practices:

Discuss and explain, with reasoning, procedural steps (mentioned and not mentioned) and the equipment used, to find the concentration (ppm or mg/L) of dissolved oxygen, in the water samples from the lake. Include any source(s) of error and limitations, and how to minimize these.

You should include in your discussion chemical equations and diagrams.

(You are NOT required to perform any calculations)

End of questions

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[illegible]

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End of Examination