



2001
PRIOR EDUCATION AUSTRALIA
EXAM 9

CHEMISTRY

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using pencil
- Draw diagrams using pencil
- A Data Sheet and a Periodic Table are provided at the back of this paper

Section I

Total marks (75)

This section has two parts, Part A and Part B

Part A

Total marks (15)

- Attempt Questions 1 – 15
- Allow about 30 minutes for this part

Part B

Total marks (60)

- Attempt Questions 16 – 28
- Allow about 1 hour and 45 minutes for this part

Section II

Total marks (25)

- Attempt ONE question from Questions 29–33
- Allow about 45 minutes for this section

Section I

Total marks (75)

Part A

Total marks (15)

Attempt Questions 1-15

Allow about 30 minutes for this part

Use multiple-choice answer sheet.

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)

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 ☐

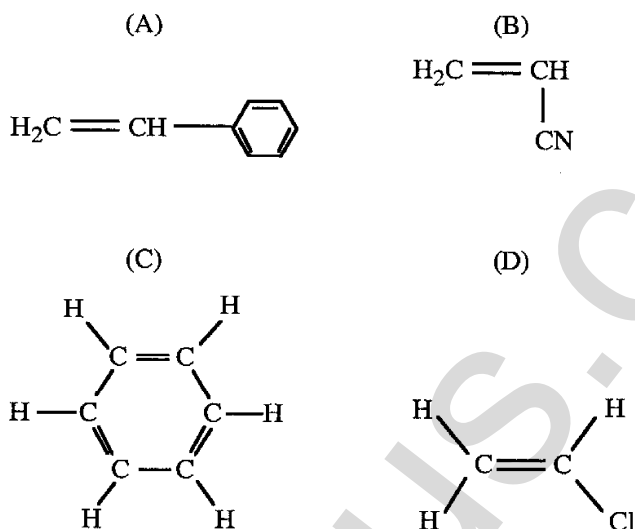
If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A ☒ B ☒ C ☐ D ☐

correct ↖

- 1 Polystyrene is a hard plastic which is widely used in toys, recreational equipment and containers.

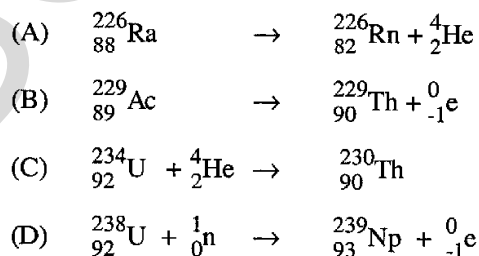
The monomer used to manufacture polystyrene is



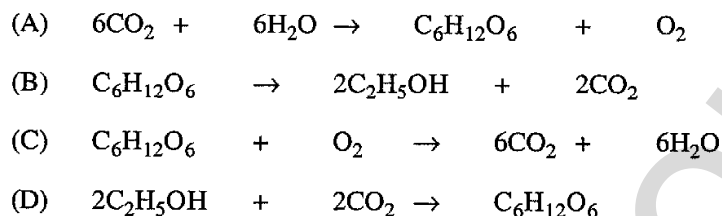
- 2 For use in industry, ethene is derived principally from

- (A) fractional distillation of petroleum.
(B) the catalytic cracking of petroleum fractions.
(C) the dehydration of ethanol using concentrated sulphuric acid.
(D) the hydrogenation of ethane using platinum as a catalyst.

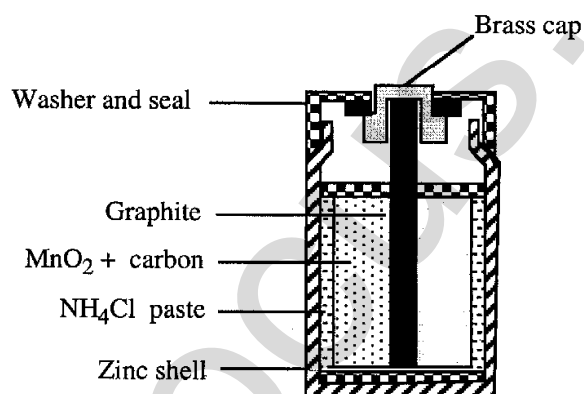
- 3 Which of the following nuclear equations relates to the production of a transuranic element in a nuclear reactor?



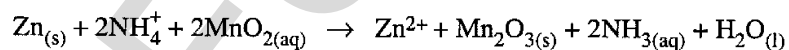
- 4 The chemical equation which is the basis for the manufacture of ethanol from plant materials is



- 5 There are a number of galvanic cells which are commonly used. A diagram of a dry or Le Clanche cell is illustrated below.



The overall reaction in this cell can be represented as



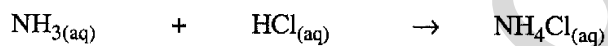
In this cell,

- (A) Zn is acting as the cathode and is being reduced to Zn^{2+} .
(B) The manganese in MnO_2 is being reduced as its oxidation number changes from +4 to +3.
(C) The ammonium ion is acting as the oxidant.
(D) The graphite rod is negative.

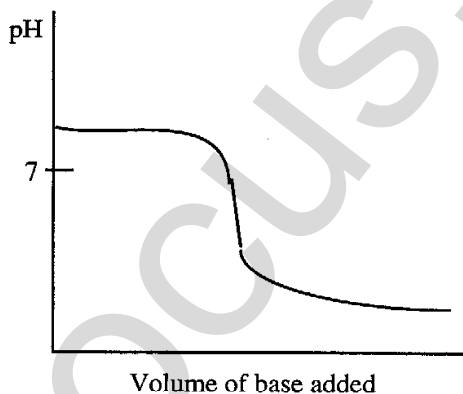
6 The combustion of octane fuel may result in the formation of

- (A) carbon dioxide gas
- (B) carbon monoxide gas
- (C) carbon particles
- (D) all of the above.

7 A 1.0 M solution of hydrochloric acid is titrated against solution of ammonia



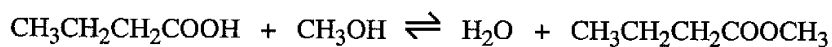
The pH curve for the titration is shown below.



The equivalence point is at a pH

- (A) less than 7 as the principal species at the equivalence point include the ammonium ion which is a Bronsted-Lowry acid.
- (B) is 7 as the ammonia has neutralised the hydrochloric acid.
- (C) is greater than 7 as hydrochloric acid is a strong acid and ammonia is a relatively weak base.
- (D) is less than 7 as hydrochloric acid is in excess at the equivalence point.

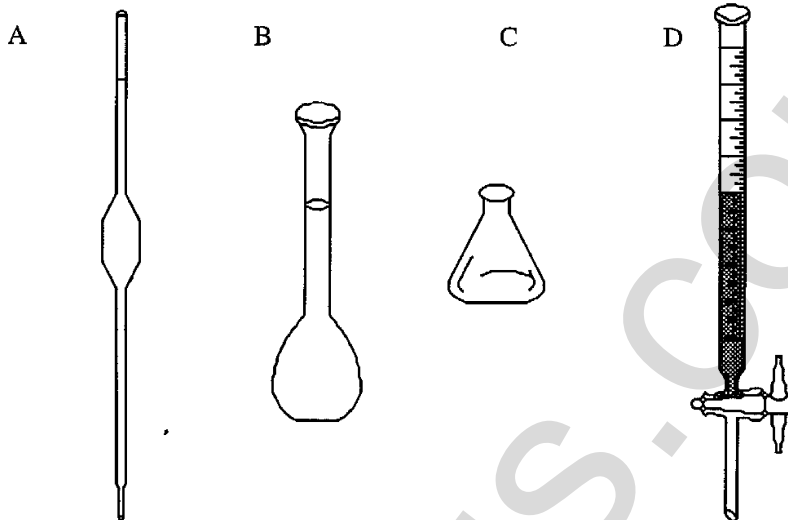
- 8 Consider the following esterification reaction:



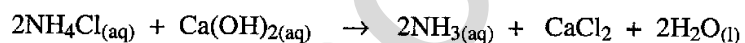
Which of the following statements is correct?

- (A) The yield of the ester formed could be increased by adding water.
 - (B) The yield of the ester formed would be reduced by adding a more concentrated solution of reactants.
 - (C) The reaction will not occur if the reactant's solution is not refluxed.
 - (D) The yield of the ester formed could be increased by adding sulphuric acid.
- 9 Which of the following species may act as a Lewis base?
- (A) boron trifluoride
 - (B) the hydrogen ion (H^+)
 - (C) ammonia
 - (D) none of the above
- 10 The organic compound with the lowest boiling point is
- (A) ethene.
 - (B) ethanoic acid.
 - (C) ethyl ethanoate
 - (D) ethanol.
- 11 Which one of the following is a correctly named isomer of 2-bromobutane?
- (A) 1-bromomethylpropane
 - (B) 3-bromobutane
 - (C) 1-chlorobutane
 - (D) 2-bromopropene

- 12 Which of the following laboratory apparatus would be used to accurately measure an aliquot of solution for titration?



- 13 Ammonia may be produced through the gentle heating of ammonium chloride and calcium hydroxide in a small amount of water.



Which of the following statements is CORRECT?

- (A) The reaction is a condensation reaction.
- (B) Once the reaction has occurred, the resulting mixture is neutral.
- (C) The ammonium ion is acting as a Bronsted-Lowry acid as it is donating a proton to the hydroxide ion.
- (D) The production of ammonia using this reaction is commonly referred to as the Haber process.

- 14 A student analyses a sample of water from a local river for a number of ions. His results are summarised in the table below.

Test	Result
addition of barium nitrate solution	white precipitate forms
addition of silver nitrate solution	white precipitate forms

The identity of the two precipitates is likely to be

- (A) barium sulphate and silver chloride.
 - (B) sodium nitrate for both.
 - (C) barium oxide and silver bromide.
 - (D) magnesium nitrate and lead nitrate.
- 15 The composition of **clean** air at **sea level** is
- (A) 78 % oxygen, 21% nitrogen, <1% water, carbon dioxide and argon.
 - (B) 78 % nitrogen, 21% oxygen, <1% water, carbon dioxide and argon.
 - (C) 75% nitrogen, 18% oxygen, 7% carbon dioxide
 - (D) 100% oxygen

Section I

Part B

Total marks (60)

Attempt Questions 16-28

Allow about 1 hour and 45 minutes for this part

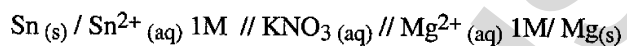
Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Question 16 (7 marks)

Marks

Consider an experiment where the following electrochemical (galvanic) cell is set up.



- (a) Draw a neat diagram of the cell that would set up and include the following labels:

2

- * anode and cathode
- * salt bridge, including the direction of movement of the ions
- * the direction of electron flow between anode and cathode.

Question 16 continues over the page

Question 16 (continued)

Marks

- (b) Write the overall equation for the reaction which occurs.

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- (c) By referring to the table of standard reduction potentials, calculate the initial potential of the cell.

2

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- (d) What is the purpose of the potassium nitrate solution?

2

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Question 17 (4 marks)

Marks

Condensation biopolymers are being considered as an alternative source of compounds obtained currently from the petrochemical industry.

- (a) What is a condensation polymer?

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- (b) Describe the structure of one condensation biopolymer you have come across in your studies.

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Question 18 (5 marks)

Marks

Ethanol can be added to petrol and used in cars without any modifications. To produce the ethanol, the fermentation process is used in which carbon dioxide gas is also a product.

- (a) Write a balanced equation for the process, using glucose ($C_6H_{12}O_6$) as the sugar being fermented, in the absence of oxygen. **1**

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- (b) If 0.5 mole of ethanol is burnt in air, 680 kJ of energy is released. Write a balanced chemical equation for this reaction and include the energy term. **2**

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- (c) The combustion of fuels such as ethanol often sometimes results in the formation of the pollutant carbon monoxide gas. Under what conditions does this occur? **2**

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Question 19 (5 marks)**Marks**

The table below shows the atmospheric levels of different gases in two different urban areas.

Component of air	Clean air	Urban Area P	Urban Area Q
Ozone (ppm)	0.02	0.22	0.05

- (a) Calculate the concentration of ozone gas in urban area P in mol L^{-1} . Assume the atmospheric pressure was 101.3 kPa and the temperature 298 K when the measurements were taken.

2

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- (b) Urban area P has elevated ozone levels.

- (i) Suggest a possible source for the ozone gas. Write a balanced chemical equation or equations for the formation of ozone gas.

2

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- (ii) What environmental / health impact may this have?

1

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Question 20. (6 marks)

Marks

An analytical chemist wanted to determine the sulfate content in an all purpose fertiliser. He weighed out 10.1 g of the lawn fertiliser. He dissolved this fertiliser in 200 mL of 0.9 M HCl, and filtered off any fertiliser that did not dissolve. To the remaining solution he added barium chloride, stirring with a glass rod. He found that a white precipitate formed. After washing this precipitate with distilled water and drying it in an oven, it had a mass of 4.84 g.

1

- (a) Write a balanced chemical equation for the formation of precipitate.

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- (b) Draw a fully labelled diagram of the apparatus you would use to separate the precipitate from the aqueous mixture.

2

- (c) Determine the percentage sulfate in the fertiliser (by mass).

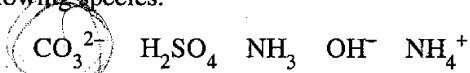
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Question 21 (4 marks)

Marks

Consider the following species.



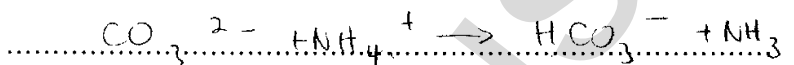
- (a) Which species will act as Lowry-Bronsted bases? Why?

2

CO_3^{2-} NH_3

- (b) Write an equation to show the species you selected in part (a) acting as a base with one of the other species listed.

1



- (c) Which species is amphoteric?

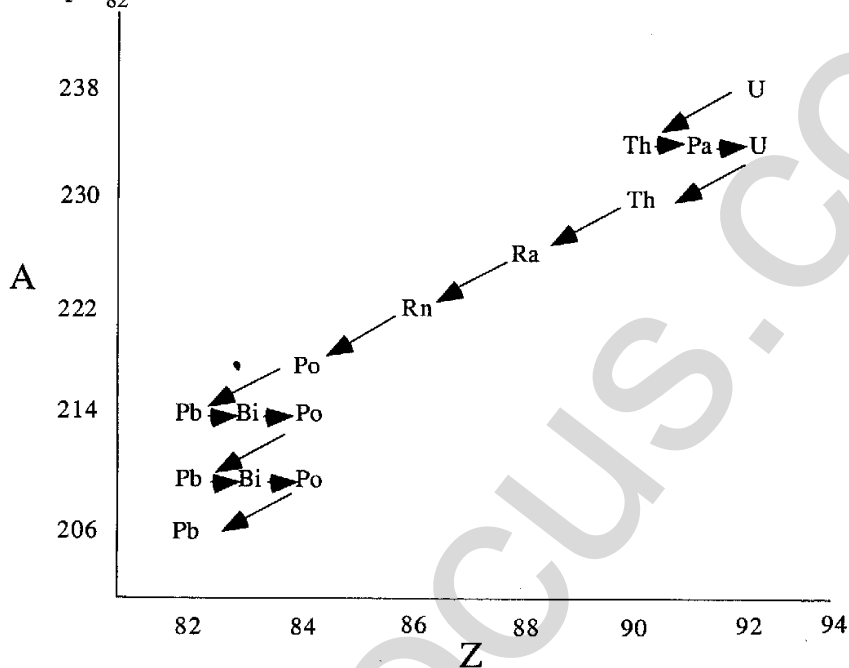
1

NH_3

Question 22 (3 marks)

Marks

The following series shows how the element uranium decays to the stable isotope, $^{206}_{82}\text{Pb}$.



- (a) What do the symbols Z and A on the y and x axes represent?

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- (b) Write a nuclear equation for the first step of the series (the alpha decay of uranium-238 decays to thorium).

1

Question 23 (5 marks)**Marks**

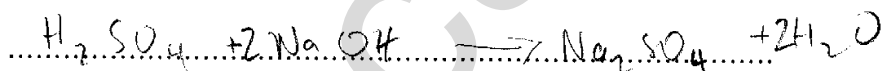
A titration is carried out in which a 0.5 mol L^{-1} sodium hydroxide solution in a burette is titrated against 20 mL of sulfuric acid solution. The volume of base required to reach the end-point was 12.5 mL.

- (a) State how you would determine experimentally when the end point of the titration had been reached. 2

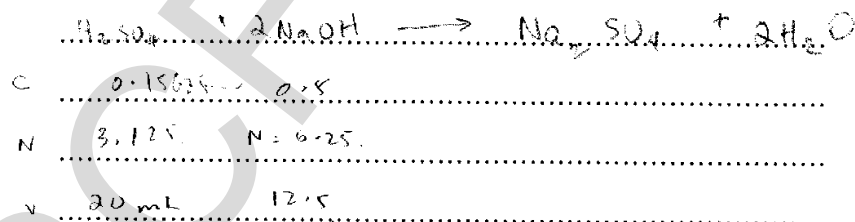
identify species $\text{H}_2\text{SO}_4 + \text{NaOH}$ pH 7
add app. indicator, a few drops
when titrating when see first
sign of colour change permanent

Bromo
Blue

- (b) Write a balanced chemical equation for the neutralisation reaction. 1



- (c) Calculate the concentration of the sulfuric acid solution. Show all working. 2



Question 24 (5 marks)

Marks

Many oxides show acidic or basic properties when placed in water.

- (a) Write the formulae of the oxides of the elements in the third period of the Periodic Table. **2**

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- (b) Describe the trend in the acidic/basic nature of the third period oxides. **3**
Your answer should include chemical equations to show the acidic/basic nature of at least one basic oxide and one acidic oxide.

+ $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{NaOH}$
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$
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Question 25 (6 marks)**Marks**

An iron ore based company uses a man made pond as a water supply in its iron manufacturing process. Once being used to cool down their steel works the water is returned to a water storage pond for reuse.

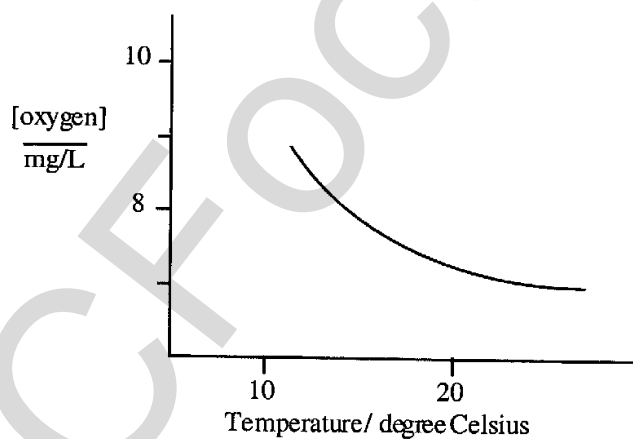
- (a) How would you measure the dissolved oxygen content of the water in the pond? **2**

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- (b) Considering the following graph, what effect would the fact that the water is used as a coolant have on the dissolved oxygen content in the pond? **1**



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Question 25 is continued over the page

Question 25 (continued)

Marks

- (c) Define the term biological oxygen demand (BOD). How is BOD measured?

3

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Question 26 (3 marks)

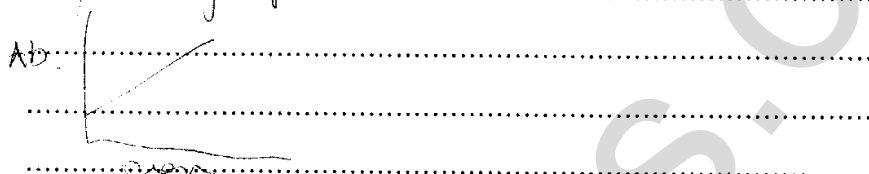
Marks

Describe the use of atomic absorption spectroscopy (AAS) in the analysis of water samples.

3

AAS helps us find [I] of metal ions in water sample. Only small [I].

Draw graph.



Question 27 (3 marks)

Marks

In your studies you have come across a number of catalysts.

3

Name one such catalyst and the reaction it which it is employed. **Describe** the role of the catalyst in this reaction and **propose** a model to account for its effect.

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Question 28 (4 marks)**Marks**

The pH of two equimolar solutions is summarised in the table below.

Acid	0.1 M HCl	0.1 M CH ₃ COOH
pH	1.0	2.87

- (a) Calculate the [H⁺] for each solution.

2

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- (b) Account for the difference in pH of each solution.

2

Eqn's Acetic \rightleftharpoons

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Section II

Total marks (25)

Attempt ONE question from Questions 29-33

Allow about 45 minutes for this part

Answer the questions in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

	Page
Question 29 Industrial Chemistry	26
Question 30 Shipwrecks and Salvage	29
Question 31 Biochemistry of Movement	31
Question 32 Chemistry of Art	33
Question 33 Forensic Chemistry	35

Question 29 -- Industrial Chemistry (25 marks)

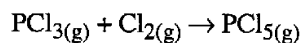
Marks

- (a) (i) Draw a flowchart outlining the steps in the double contact sulphuric acid manufacturing process. **3**
- (ii) Describe one way in which heat energy is conserved in the process. **1**
- (iii) Sulphuric acid can act as an oxidising agent. Write down the reaction between solid zinc metal and;
- (α) dilute sulphuric acid **1**
- (β) concentrated sulphuric acid **1**
- (iv) Dilute sulphuric acid is able to oxidise zinc, but is unable to oxidise the more active metal aluminium. Explain this observation. **1**
- (b) The following diagram is a simplified representation of a soap molecule.



- (i) Explain the causes of the hydrophilic nature of the 'head', and the hydrophobic nature of the 'tail' of the soap molecule. **2**
- (ii) In solution, soap molecules form micelles with grease. Describe a soap micelle, and account for its stability in a soap solution. **2**
- (iii) Describe the difference between a soap and a detergent. **2**
- (iv) Nonionic detergents are useful because they are not considerably affected by metal ions in water. Explain this observation, and describe how an anionic detergent forms stable micelles in solution. **2**
- (v) Name one use for nonionic detergents. **1**

- (c) Consider the industrial manufacture of phosphorus pentachloride given by the reaction;



The following table contains equilibrium and residence time information for the reaction.

Temperature (°C)	Equilibrium Constant	Time required to produce 1 tonne of sulphur dioxide
50	7.5×10^7	5 hours
150	1×10^4	15 minutes
250	100	20 seconds
350	5	0.5 seconds
450	0.1	0.05 seconds

Question 29 continues on page 28

- (i) Explain whether you think the reaction is endothermic or exothermic. 1
- (ii) Write down the equilibrium constant for this reaction. 1
- (ii) Qualitatively describe the effect on the equilibrium, and equilibrium constant, of;
- (α) increasing temperature 1
- (β) increasing pressure 1
- (iii) Which temperature favours
- (α) the largest volume of phosphorus pentachloride produced 1
- (β) the most rapid production of phosphorus pentachloride 1
- (iv) Clint Crop, an engineer in charge of a PCl_5 production facility, wanted to determine the appropriate temperature to operate the reactor. Explain the trade-off Clint is faced with. 2
- (v) What could be done to overcome this trade-off (assuming that cost is not an issue)? 1

End of Question 29

Question 30 -- Shipwrecks and Salvage (25 marks)

Marks

- (a) Rusting is a huge problem across a number of different industries. A variety of methods can be used to address these problems with new and fancier methods under development.
- (i) What are surface alloys? Indicate how surface alloys resist corrosion processes. **3**
- (ii) (α) What is galvanised iron? **1**
- (β) How does galvanising iron protect it against corrosion? Include any relevant chemical equations in your answer. **3**
- (b) There are many different materials that may be found within a ship wreck including metals, textiles, wood and leather, all of which have been subject to the 'salty environment' of the surrounding ocean. A marine archaeologist decides that he wants to restore a leather jacket discovered in an old shipwreck.
- (i) Explain how you would remove impregnated salts from the leather jacket. **2**
- (ii) Explain what problems might result if the leather jacket were simply 'dried out'. **2**
- (iii) After the impregnated salts have been removed from the object suggest a method of further conserving the object. **1**

Question 30 continues on page 30

Question 30. (continued)

Marks

(c) Minerals in the ocean have a number of different sources including:

- leaching of rainwater from terrestrial environments and
- from the hydrothermal vents in midocean ridges.

(i) Identify two minerals that have their origins in hydrothermal vents.

2

(ii) Describe the process by which minerals are dissolved from hydrothermal vents.

2

(d) Faraday was an eminent and ingenious scientist who contributed much to our understanding of electron transfer reactions.

(i) Describe Faraday's contribution to our understanding of redox reactions.

3

(ii) Describe how Galvani's interaction with frogs led to his contribution to our understanding of redox reactions.

2

(e) Potassium dichromate is an extremely powerful oxidising agent. When a 5 gram mass of nickel is placed in a solution of acidified potassium dichromate the nickel was observed to dissolve.

(i) Account for this observation by writing half equations for the reaction which took place.

2

(ii) Determine the number of moles of dichromate ions that must have reacted to dissolve all of the nickel.

2

End of Question 30

Question 31 -- Biochemistry of Movement (25 marks)

Marks

- (a) Compare and contrast the complete oxidation of palmitic acid and glucose to carbon dioxide and water. In your answer, include
- the pathways by which metabolism occurs;
 - the site of metabolism;
 - a brief discussion of the approximate amount of energy produced in each case.
- (b) Briefly discuss the sliding filament theory of muscle contraction. Include in your answer the role of ATP in this process and name the contractile components in muscle.
- (c) A student conducted an experiment to test the effect of temperature on the activity of an enzyme. He selected catalase, which is an enzyme found in chicken liver tissue, and catalyses the decomposition of hydrogen peroxide into water and oxygen gas. Using fresh chicken liver which had been treated as given below, he set up four test tubes in the dark:
- Test tube #1 contained 10mL of hydrogen peroxide.
 - Test tube #2 contained 10mL of hydrogen peroxide plus a 1 g piece of chicken liver which had been stored at 4°C for 20 minutes.
 - Test tube #3 contained 10 mL of hydrogen peroxide, plus a 1 g piece of chicken liver which had been heated a water bath at 37°C for 20 minutes.
 - Test tube #4 contained 10 mL of hydrogen peroxide plus a 1 g piece of chicken liver which had been heated in a water bath at 70°C for 20 minutes, and then cooled back to 37°C before it was added.
- (a) What is produced in Test tube #1?
- (b) Explain why you would expect test tube #3 to be more reactive than test tube #2.
- (c) Test tube #4 showed no reaction. Explain.

Question 31 continues on page 32

Question 31. (continued)

Marks

- | | | |
|-----|---|---|
| (d) | The major purpose of oxidising fuels is to produce "ATP". Briefly explain what ATP is and its role within the body. | 2 |
| (e) | (i) What is the difference between the primary, secondary and tertiary structures of proteins? | 3 |
| | (ii) Discuss the types of interactions which are present in the tertiary structure of a protein. | 3 |

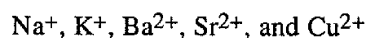
End of Question 31

Question 32 -- Chemistry of Art (25 marks)

Marks

- (a) Materials may be coloured using a number of basic methods. Using the knowledge you have gained in your studies, briefly outline at least two ways materials may be coloured. **3**

- (b) **Describe** the experiment you performed to identify the flame colour of the following ions. **6**



Your answer should include a description of the method, the flame colour of the ions, and any safety precautions.

Explain the origin of the flame colour.

- (c) Cobalt occurs in the minerals cobaltite, smaltite, and erythrite, and is often associated with nickel, silver, lead, copper, and iron ores, from which it is most frequently obtained as a by-product. It is also present in meteorites.

The salts have been used for centuries to produce brilliant and permanent blue colours in porcelain, glass, pottery, tiles, and enamels. It is the principal ingredient in Sevre's and Thenard's blue. A solution of the chloride is used as a sympathetic ink.

- (i) Write the electron configuration of the cobalt(II) ion in sp notation. **1**
- (ii) Draw the Lewis electron dot formula for one complex of cobalt. Identify the colour of the complex ion you have drawn. **3**

Question 32 continues on page 34

Question 32. (continued)

Marks

- (d) In your studies you have processed information to identify and analyse the chemical composition of a range of pigments. Select three pigments you have studied. For each identify
- the chemical composition;
 - the source of the pigment;
 - the use(s) of the pigment.
- (e) Outline the use of infra-red and ultra-violet light in the analysis and identification of pigments and their chemical composition.
- (f) Does ammonia function as a Lewis acid, Lewis base or neither when forming a complex ion with copper (II) ion? Using appropriate diagrams and equations, explain your answer.
- (g) The discoveries of emission and absorption spectra are examples of important developments in the history of chemistry.
- Assess the impact of the discoveries on the development of one analytic instrument used by forensic chemists in the study of pigments and paints in art works.

End of Question 32

Question 33 -- Forensic Chemistry (25 marks)

Marks

- (a) What of the biggest distinctions jobs of a chemist is to be able to classify substances into different classes: for example inorganic and organic compounds or acids and bases.
- (i) Suggest a simple method which you could use to determine if a compound was more likely to be inorganic or organic. 2
- (ii) How might you determine whether a solid was an acid or a base if you were told that the solid was insoluble. 2
- (iii) How might you quickly distinguish between a carbohydrate and a protein? 2
- (b) DNA profiling is an amazing advancement which allows the accurate identification of human tissue samples.
- (i) Describe briefly the steps undertaken to obtain a DNA profile. 4
- (ii) Briefly explain by referring to the part of the molecule examined by DNA profiling, how a DNA profile is unique to each individual. 2
- (iii) Analyse the impact that DNA profiling may have on modern forensic investigations. Include a specific example in your answer. 2

Question 33 continues on page 36

Question 33. (continued)

Marks

- (c) Nectar from flowers contains sucrose. When the nectar is tested with Benedict's reagent, a negative result is obtained. Bees have an enzyme which causes the inversion of sucrose, so that honey gives a positive result.
- (i) What does Benedict's reagent test for? 2
- (ii) What is observed with a positive result? 1
- (iii) What other test could be used in place of the Benedict's test and what occurs with a positive result? 2
- (d). There are many different types of proteins including structural proteins and globular proteins.
- (i) Identify 2 different proteins from each of these classes. 2
- (ii) How might a forensic investigator distinguish between different types of structural proteins? 2
- (e) Distinguishing between different organic compounds is one of the fundamental components of investigative chemistry. Describe a test (other than testing pH), which you could perform which would enable you to distinguish between propanol and propanoic acid. 2

End of Question 33

DATA SHEET

Numerical constants

Avagadro's constant, N	$6.022 \times 10^{23} \text{ mol}^{-1}$	Gas constant, R	$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann's constant, k	$1.381 \times 10^{-23} \text{ J K}^{-1}$	Mass of electron, m_e	$0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$
Elementary charge, e	$1.602 \times 10^{-19} \text{ C}$	Mass of neutron, m_n	$9.109 \times 10^{-31} \text{ kg}$
Faraday's constant, F	$96\,490 \text{ C mol}^{-1}$	Mass of proton, m_p	$1.675 \times 10^{-27} \text{ kg}$
Volume of 1 mole ideal gas at 101.3 kPa (1 atm):	22.41 L		
at 0°C (273 K)	24.47 L		
at 25°C (298 K)			

Standard Electrode Potentials

$\text{K}^+ + \text{e}^-$	\rightleftharpoons	$\text{K}_{(\text{s})}$	-2.92 V
$\text{Ba}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Ba}_{(\text{s})}$	-2.90 V
$\text{Ca}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Ca}_{(\text{s})}$	-2.87 V
$\text{Na}^+ + \text{e}^-$	\rightleftharpoons	$\text{Na}_{(\text{s})}$	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Mg}_{(\text{s})}$	-2.36 V
$\text{Al}(\text{OH})_3 + 3\text{e}^-$	\rightleftharpoons	$\text{Al}^+ + 4\text{OH}^-$	-2.33 V
$\text{Al}^{3+} + 3\text{e}^-$	\rightleftharpoons	$\text{Al}_{(\text{s})}$	-1.66 V
$\text{H}_2\text{O} + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_2(\text{g}) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Zn}_{(\text{s})}$	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Fe}_{(\text{s})}$	-0.41 V
$\text{CuO} + 2\text{e}^- + \text{H}_2\text{O}$	\rightleftharpoons	$\text{Cu}_{(\text{s})} + 2\text{OH}^-$	-0.36 V
$\text{Ni}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Ni}_{(\text{s})}$	-0.23 V
$\text{Sn}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Sn}_{(\text{s})}$	-0.14 V
$\text{CO}_{2(\text{g})} + 4\text{H}^+ + 4\text{e}^-$	\rightleftharpoons	$\text{HCHO} + \text{H}_2\text{O}$	-0.07 V
$\text{CO}_{2(\text{g})} + 4\text{H}^+ + 4\text{e}^-$	\rightleftharpoons	$\frac{1}{6}\text{C}_6\text{H}_{12}\text{O}_6 (\text{glucose}) + \text{H}_2\text{O}$	-0.01 V
$\text{H}^+ + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_{2(\text{g})}$	0.00 V
$\text{CO}_{2(\text{g})} + 6\text{H}^+ + 6\text{e}^-$	\rightleftharpoons	$\text{CH}_3\text{OH} + \text{H}_2\text{O}$	0.03 V
$\text{CO}_{2(\text{g})} + 8\text{H}^+ + 8\text{e}^-$	\rightleftharpoons	$\text{CH}_{4(\text{g})} + 2\text{H}_2\text{O}$	0.17 V
$\text{AgCl}_{(\text{s})} + \text{e}^-$	\rightleftharpoons	$\text{Ag}_{(\text{s})} + \text{Cl}^-$	0.22 V
$\text{HCOH} + 2\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	CH_3OH	0.24 V
$\text{Cu}^{2+} + 2\text{e}^-$	\rightleftharpoons	$\text{Cu}_{(\text{s})}$	0.35 V
$\frac{1}{2}\text{O}_{2(\text{g})} + \text{H}_2\text{O} + 2\text{e}^-$	\rightleftharpoons	2OH^-	0.40 V
$\text{HCOH} + 4\text{H}^+ + 4\text{e}^-$	\rightleftharpoons	$\text{CH}_{4(\text{g})} + \text{H}_2\text{O}$	0.41 V
$\text{Cu}^+ + \text{e}^-$	\rightleftharpoons	$\text{Cu}_{(\text{s})}$	0.52 V
$\frac{1}{2}\text{I}_{2(\text{s})} + \text{e}^-$	\rightleftharpoons	I^-	0.54 V
$\frac{1}{2}\text{I}_{2(\text{aq})} + \text{e}^-$	\rightleftharpoons	I^-	0.62 V
$\text{Ag}^+ + \text{e}^-$	\rightleftharpoons	$\text{Ag}_{(\text{s})}$	0.80 V
$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^-$	\rightleftharpoons	$\text{NO}_{(\text{g})} + 2\text{H}_2\text{O}$	0.96 V
$\frac{1}{2}\text{Br}_{2(\text{aq})} + \text{e}^-$	\rightleftharpoons	Br^-	1.09 V
$\frac{1}{2}\text{O}_{2(\text{g})} + 2\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	H_2O	1.23 V
$\frac{1}{2}\text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	\rightleftharpoons	$\text{Cr}^{3+} + \frac{7}{2}\text{H}_2\text{O}$	1.33 V
$\frac{1}{2}\text{Cl}_{2(\text{g})} + \text{e}^-$	\rightleftharpoons	Cl^-	1.36 V

atomic number

atomic number	79	Au	197.0	Gold
atomic mass				

1	H	1.008	Hydrogen
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2	He 4.003	Helium	10	Ne 20.18	Neon	18	Ar 39.95	Argon	36	Kr 83.80	Krypton	86	Rn —	Radon
3			9	F 19.00	Fluorine	17	Cl 35.45	Chlorine	35	Br 79.90	Bromine	85	At —	Astatine
4			8	O 16.00	Oxygen	16	S 32.06	Sulfur	34	Se 78.96	Selenium	84	Po —	Polonium
5			7	N 14.01	Nitrogen	15	P 30.97	Phosphorus	33	As 74.92	Arsenic	83	Bi 209.0	Bismuth
6			6	C 12.01	Carbon	14	Si 28.09	Silicon	32	Ge 72.59	Germanium	82	Pb 207.2	Lead
7			5	B 10.81	Boron	13	Al 26.98	Aluminum	31	Ga 69.72	Gallium	81	Tl 204.4	Thallium
8			4	Be 9.01	Beryllium	12	Mg 24.31	Magnesium	30	Zn 65.39	Zinc	80	Hg 200.6	Mercury
9			3	Li 6.94	Lithium	11	Na 22.99	Sodium	29	Cu 63.55	Copper	79	Au 197.0	Gold
10			2	H 1.01	Hydrogen	10	Ne 20.18	Neon	18	Ar 39.95	Argon	36	Kr 83.80	Krypton
11			1	H 1.01	Hydrogen	9	F 19.00	Fluorine	17	Cl 35.45	Chlorine	35	Br 79.90	Bromine
12			1	H 1.01	Hydrogen	8	O 16.00	Oxygen	16	S 32.06	Sulfur	34	Se 78.96	Selenium
13			2	He 4.003	Helium	10	Ne 20.18	Neon	18	Ar 39.95	Argon	36	Kr 83.80	Krypton
14			3	Li 6.94	Lithium	11	Na 22.99	Sodium	29	Cu 63.55	Copper	79	Au 197.0	Gold
15			4	Be 9.01	Beryllium	12	Mg 24.31	Magnesium	30	Zn 65.39	Zinc	80	Hg 200.6	Mercury
16			5	B 10.81	Boron	13	Al 26.98	Aluminum	31	Ga 69.72	Gallium	81	Tl 204.4	Thallium
17			6	C 12.01	Carbon	14	Si 28.09	Silicon	32	Ge 72.59	Germanium	82	Pb 207.2	Lead
18			7	N 14.01	Nitrogen	15	P 30.97	Phosphorus	33	As 74.92	Arsenic	83	Bi 209.0	Bismuth
19			8	O 16.00	Oxygen	16	S 32.06	Sulfur	34	Se 78.96	Selenium	84	Po —	Polonium
20			9	F 19.00	Fluorine	17	Cl 35.45	Chlorine	35	Br 79.90	Bromine	85	At —	Astatine
21			10	Ne 20.18	Neon	18	Ar 39.95	Argon	36	Kr 83.80	Krypton	86	Rn —	Radon

3	Li 6.941 Lithium	4	Be 9.012 Beryllium
11	Na 22.99 Sodium	12	Mg 24.31 Magnesium
19	K 39.10 Potassium	20	Ca 40.08 Calcium
37	Rb 85.47 Rubidium	38	Sr 87.62 Strontium
55	Cs 132.9 Cesium	56	Ba 137.3 Barium
87	Fr — Francium	88	Ra — Radium

58	Ce Cerium	59	Pr Praseodymium	60	Nd Neodymium	61	Pm Promethium	62	Sm Samarium	63	Eu Europium	64	Gd Gadolinium	65	Tb Terbium	66	Dy Dysprosium	67	Ho Holmium	68	Er Erbium	69	Tm Thulium	70	Yb Ytterbium	71	Lu Lutetium
90	Th Thorium	91	Pa Protactinium	92	U Uranium	93	Np Neptunium	94	Pu Plutonium	95	Am Americium	96	Cm Curium	97	Bk Berkelium	98	Cf Californium	99	Es Einsteinium	100	Fm Fermium	101	Md Mendelevium	102	No Nobelium	103	Lr Lawrencium