



Dalziel High School
Chemistry Department



1996 CSYS

CERTIFICATE OF
SIXTH YEAR
STUDIES
1996

WEDNESDAY, 15 MAY
9.30 AM - 12.00 NOON

CHEMISTRY
Paper

All questions should be attempted.

Necessary data will be found in the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 edition) which is provided.

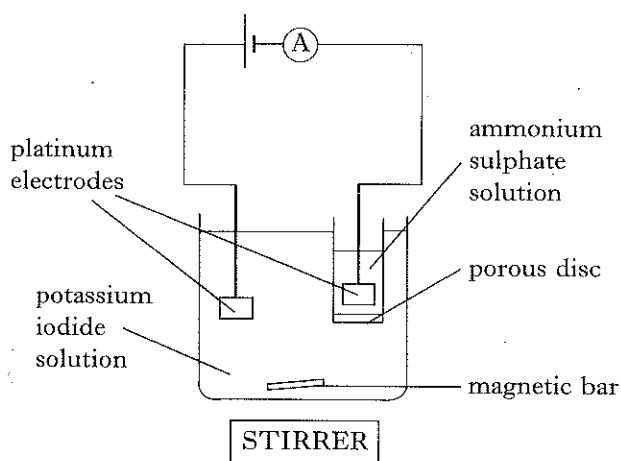


1. At temperatures below 84 K, argon exists as a crystalline solid. Argon atoms are held together in the solid by
- covalent bonding
 - ionic bonding
 - hydrogen bonding
 - van der Waals bonding.

2. Which one of the following is **not** suitable for the preparation of a primary standard in volumetric analysis?

- Anhydrous sodium carbonate
- Sodium hydroxide
- Oxalic acid
- E.D.T.A.

3. Iodine can be generated in the following cell.



The apparatus was switched on for 2 minutes and the current flowing was 10 mA. How many moles of iodine were produced?

- 6.2×10^{-6}
- 3.1×10^{-6}
- 6.2×10^{-5}
- 1.6×10^{-4}

4. Which of the following will react with 100 cm^3 of 0.1 mol l^{-1} hydrochloric acid so that both of the reactants would be used up?

- 0.5 g calcium carbonate
- 100 cm^3 of 0.1 mol l^{-1} barium hydroxide solution
- 0.24 g magnesium
- 25 cm^3 of 0.2 mol l^{-1} silver nitrate solution

5. Compared to visible radiation (light), infra-red radiation has a

- shorter wavelength and higher frequency
- longer wavelength and lower velocity
- longer wavelength and lower frequency
- shorter wavelength and higher velocity.

6. The electronic configuration of the Mn^{2+} ion is

- $[\text{Ar}] 3d^5 4s^2$
- $[\text{Ar}] 3d^5$
- $[\text{Ar}] 3d^3 4s^2$
- $[\text{Ar}] 3d^7 4s^2$.

([Ar] = electron configuration of argon)

7. Which is a correct statement about a catalyst?

For a chemical reaction it

- does not alter the value of the rate constant
- alters the value of the equilibrium constant
- alters the mechanism
- has no effect on the value of the activation energy.

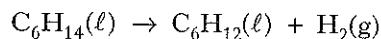
8. The rate of a particular chemical reaction is first order with respect to each of two reactants. The units of k , the rate constant, for the reaction are

- $\text{mol l}^{-1} \text{ s}^{-1}$
- $\text{l mol}^{-1} \text{ s}^{-1}$
- $\text{l}^2 \text{ mol}^{-2} \text{ s}^{-2}$
- $\text{mol}^2 \text{ l}^{-2} \text{ s}^{-1}$.

[Turn over

9. For the reaction

hexane \rightarrow cyclohexane + hydrogen



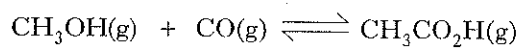
$$\Delta H^\circ = 44 \text{ kJ mol}^{-1}$$

$$\Delta S^\circ = 42 \text{ J K}^{-1} \text{ mol}^{-1}$$

which of the following statements is true?

- A The reaction is not feasible at any temperature.
- B The reaction is only feasible above a certain temperature.
- C The reaction is only feasible below a certain temperature.
- D The reaction is feasible at all temperatures.

10. Ethanoic acid can be manufactured by the Monsanto Process.

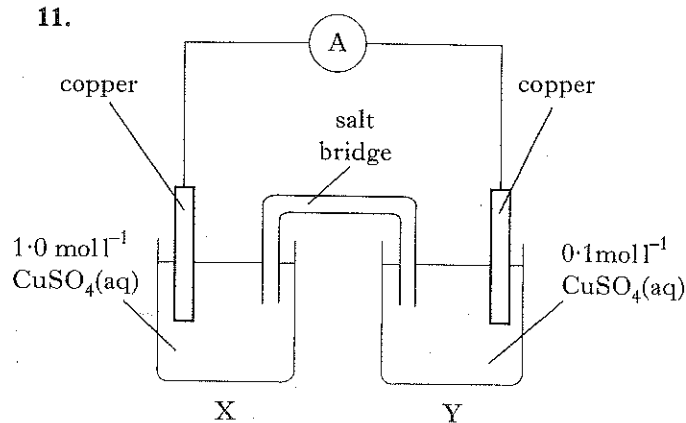


$$\text{At } 300^\circ\text{C}, \Delta H_{\text{(forward reaction)}} = -175 \text{ kJ mol}^{-1}$$

Which of the following statements is **not** true?

- A The entropy of the product is less than that of the reactants.
- B The percentage conversion to ethanoic acid is greater at lower temperatures.
- C A high pressure will favour the percentage conversion to ethanoic acid.
- D The use of a catalyst increases the percentage conversion to ethanoic acid.

11.



Which of the following will occur in the above cell?

- A The blue colour in Y will become less intense.
- B The concentration of the solution in X will increase.
- C The mass of the electrode in Y will decrease.
- D Electrons will flow from X to Y through the ammeter.

12. ΔG° gives an indication of the position of the equilibrium for a reaction.

The equilibrium lies on the side of the products when ΔG° is

- A large and positive
- B zero
- C one
- D large and negative.

13. When an aluminium atom of mass number 27 is bombarded by an alpha particle, a phosphorus atom of mass number 30 is formed.

In this process, the particle emitted is

- A an electron
- B a hydrogen atom
- C a proton
- D a neutron.

14. The standard entropy values ($\text{J K}^{-1} \text{mol}^{-1}$) for a number of compounds are shown below.

$\text{CH}_4(\text{g})$	$\text{O}_2(\text{g})$	$\text{CO}_2(\text{g})$	$\text{H}_2\text{O}(\text{g})$	$\text{H}_2\text{O}(\ell)$
S° 186	205	214	189	70

The standard entropy change ($\text{J K}^{-1} \text{mol}^{-1}$) for the complete combustion of one mole of methane is

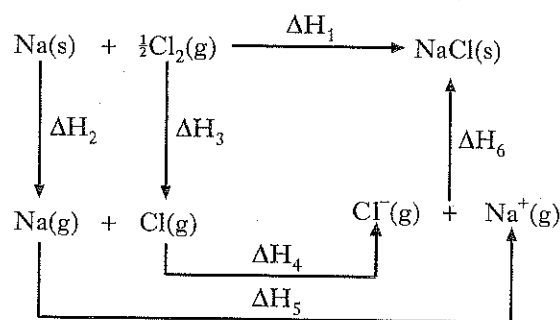
- A -4
 B -37
 C -242
 D +242.
15. Which of the following structural features is **least** desirable in hydrocarbons used in petrol?
- A Branched chains
 B Saturated rings
 C Straight chains
 D Aromatic rings
16. Elements U, V, W and X form ions as shown in the table.

Ion	Ionic radius/nm
U^+	0.095
V^+	0.133
W^-	0.136
X^-	0.181

Which of the following compounds would be expected to have the highest melting point?

- A UW
 B UX
 C VW
 D VX

Questions 17 and 18 refer to the Born-Haber cycle below.



17. The enthalpy term which involves electron gain (electron affinity) is
- A ΔH_1
 B ΔH_2
 C ΔH_3
 D ΔH_4 .
18. The main enthalpy term which ensures that ΔH_1 is exothermic is
- A ΔH_3
 B ΔH_4
 C ΔH_5
 D ΔH_6 .
19. Which of the following salts has the highest degree of ionic character?
- A LiCl
 B CsCl
 C CsI
 D LiF
20. Which of the following compounds would be expected to have the highest boiling point?
- A $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$
 B $\text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_3$
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

Turn over

21. Which of the following can be distinguished by the use of 2,4-dinitrophenylhydrazone derivatives?

- A Propan-1-ol and propan-2-ol
- B Ethanal and propanal
- C Ethanoic acid and benzoic acid
- D Methoxyethane and ethoxyethane

22. Ethanal reacts with an alkaline solution of iodine to form a yellow solid called iodoform, CHI_3 . This reaction can be repeated with any compound containing the $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-$ group or

with one which can be readily oxidised to form this group. Iodoform will **not** be produced by

- A ethanol
- B propanone
- C butan-2-ol
- D pentan-3-one.

23. Which of the following represents a chain termination step?

- A $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{C}_2\text{H}_6$
- B $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$
- C $\text{CH}_4 + \text{Cl}\cdot \rightarrow \text{CH}_3\cdot + \text{HCl}$
- D $\text{CH}_3\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$

24. Which of the following will attack propane molecules?

- A Sodium atoms
- B Chlorine atoms
- C Sodium ions
- D Chlorine molecules

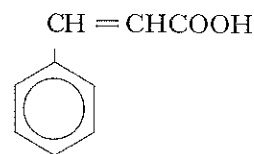
25. A liquid is immiscible with water, is highly flammable and is comparatively unreactive. It could be

- A $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- C $\text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$.

26. In industry, much carboxylic acid manufacture is carried out by

- A direct oxidation of aldehydes
- B direct oxidation of ketones
- C direct oxidation of alkanes
- D direct oxidation of alkenes.

27.



The above compound should **not** react with

- A Benedict's reagent (alkaline $\text{Cu}^{2+}(\text{aq})$)
- B nitric acid/sulphuric acid mixture
- C bromine water
- D ethanol.

28. The vapour of a compound containing only carbon, hydrogen and oxygen was passed over hot copper(II) oxide. The copper(II) oxide was reduced to copper, and the gaseous product was condensed. This product was soluble in water, forming a neutral solution.

The original compound could have been

- A an aldehyde
- B a ketone
- C a secondary alcohol
- D a tertiary alcohol.

29. Which halide will be most resistant to attack by nucleophilic reagents?

- A $\text{CH}_3\text{CH}_2\text{Br}$
- B $\text{CH}_3\text{C}(\text{CH}_3)_2\text{Cl}$
- C $\text{CH}_3\text{CH}(\text{Cl})\text{CH}_3$



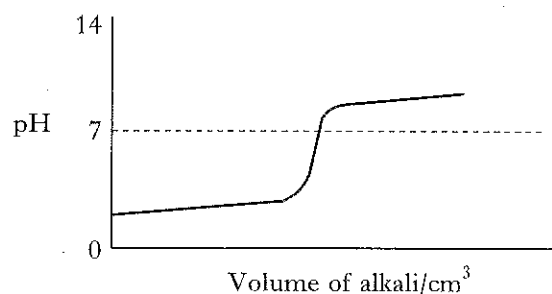
30. A complex ion with the name hexaamminetitanium(III) will have the formula

- A $[\text{Ti}(\text{CH}_3\text{NH}_2)_6]^{3+}$
- B $[\text{Ti}(\text{NH}_3)_6]^{3+}$
- C $[\text{Ti}(\text{NH}_4^+)_6]^{3-}$
- D $[\text{Ti}(\text{NH}_3)_6]^{3-}$

31. The pH of a solution of ethanoic acid ($\text{pK}_a = 4.8$), with concentration 0.01 mol l^{-1} is

- A 1.4
- B 3.4
- C 4.8
- D 5.8

32. pH measurements were recorded as the chemicals below were titrated. Which reaction gave rise to the titration curve below?



- A Nitric acid and ammonia solution
- B Sulphuric acid and potassium hydroxide
- C Ethanoic acid and ammonia solution
- D Ethanoic acid and sodium hydroxide

33. Which of the following changes would account for a rise in the pH of a solution from 6 to 8?

- A Decreasing the hydrogen ion concentration one hundred times
- B Increasing the hydrogen ion concentration ten times
- C Increasing the hydrogen ion concentration by one third
- D Doubling the concentration of the hydroxide ion

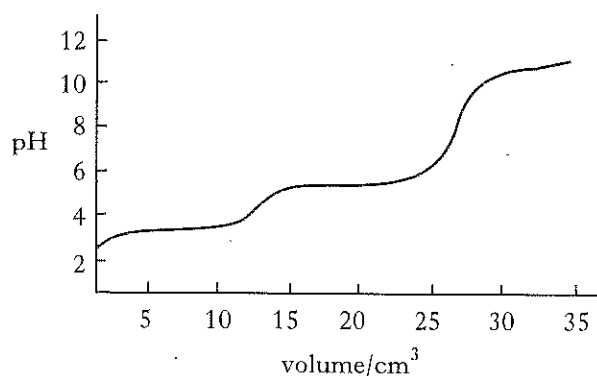
34. Which of the following could have an equilibrium constant equal to 1×10^{-55} ?

- A $\text{CH}_3\text{OH}(\ell) + \text{CH}_3\text{COOH}(\ell) \rightleftharpoons \text{CH}_3\text{COOCH}_3(\ell) + \text{H}_2\text{O}(\ell)$
- B $\text{Zn}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightleftharpoons \text{Zn}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$
- C $3\text{Ni}(\text{s}) + 2\text{Cr}^{3+}(\text{aq}) \rightleftharpoons 3\text{Ni}^{2+}(\text{aq}) + 2\text{Cr}(\text{s})$
- D $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightleftharpoons \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$

35. A buffer solution can be made from a

- A strong acid and a salt of that acid
- B weak acid and a salt of that acid
- C strong acid and a salt of a weak acid
- D weak acid and a salt of a strong acid.

36. The neutralisation of 10 cm^3 of a dicarboxylic acid was followed using a pH meter. A graph of pH against volume of alkali was plotted.



Which could be the best indicator pH range to detect the end point of the reaction when the acid was just completely neutralised?

- A 3.1–4.4
- B 3.8–5.4
- C 6.8–8.4
- D 9.3–10.5

[Turn over

37. An aqueous solution of potassium permanganate is purple in colour.

The colour of light absorbed by this solution is

- A red
- B blue
- C purple
- D green.

38. Which of the following ions is **least** likely to be coloured?

- A $\text{Ni}(\text{H}_2\text{O})_6^{2+}$
- B $\text{Zn}(\text{NH}_3)_4^{2+}$
- C $\text{Cr}(\text{NH}_3)_6^{3+}$
- D $\text{Ti}(\text{H}_2\text{O})_6^{3+}$

39. What is the oxidation state of chromium in $\text{Cr}_2\text{O}_7^{2-}$?

- A -2
- B +2
- C +4
- D +6

40. Which of the following elements can exhibit the highest oxidation number?

- A Manganese
- B Cobalt
- C Titanium
- D Iron

41. The boxes in the grid below contain certain ion-electron equations.

A	$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	B	$\text{Br}_2(\ell) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	C	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$
D	$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\ell)$	E	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	F	$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\ell)$

Identify the ion-electron equation(s) containing

- the most powerful oxidising agent
- the **two** species which can convert bromide ions to bromine
- two** species which, coupled in a cell, give an E° value of 1.15V
- two** species which, coupled in a cell, give the largest E° value.

42. The boxes in the grid below contain descriptions of the shapes of some molecules and ions.

A	linear	B	pyramidal	C	bent or V-shaped
D	tetrahedral	E	trigonal bipyramidal	F	trigonal planar

Identify the shape of each of the following molecules.

- NH_3
- BeCl_2
- CO_2
- PCl_5

43. The boxes in the grid below show possible steps in the extraction of metals from their ores.

A	Reduction of the metal oxide with carbon	B	Precipitation of (hydrated) metal oxide from a solution of its ore in alkali	C	Displacement of the metal from its oxide by another metal
D	Electrolysis of the molten metal oxide	E	Reaction of the metal oxide with chlorine	F	Displacement of the metal from its chloride by another metal

Identify the **two** steps involved in the commercial extraction of

- (a) titanium
- (b) aluminium.

1. Consider the following reactions and their values for ΔG° and ΔH° at 298K.

Reaction	$\Delta G^\circ/\text{kJ mol}^{-1}$	$\Delta H^\circ/\text{kJ mol}^{-1}$
(i) $\frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{Cl}_2(\text{g}) \longrightarrow \text{HCl}(\text{g})$	-95	-92
(ii) $2\text{Al}(\text{s}) + 1\frac{1}{2}\text{O}_2(\text{g}) \longrightarrow \text{Al}_2\text{O}_3(\text{s})$	-1576	-1669
(iii) $\text{NH}_4\text{Cl}(\text{s}) \longrightarrow \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$	-7	+16

- (a) Reaction (ii) has the greatest difference in the values of ΔG° and ΔH° .
Suggest a reason for this difference. 1
- (b) From the values given for reaction (iii), it can be concluded that ammonium chloride dissolves **spontaneously** in water under standard conditions with a **drop** in temperature.
Why can we come to these two conclusions? 2
- (c) Calculate the entropy change for reaction (i) at 298K. 2
- (5)**

2. Anhydrous malonic acid has a relative formula mass of 104. 1.28 g of hydrated malonic acid, $\text{CH}_2(\text{COOH})_2 \cdot n\text{H}_2\text{O}$, was dissolved in water and made up to 250 cm^3 in a standard flask. 25.0 cm^3 of this acid was titrated with 0.1 mol l^{-1} sodium hydroxide. 18.2 cm^3 of the alkali was required for complete neutralisation of the acid.

- (a) Calculate the number of moles of acid that has been neutralised in the titration. 2
- (b) Calculate the mass of water in the 1.28 g of the hydrated sample. 2
- (c) Find the value for n in the formula $\text{CH}_2(\text{COOH})_2 \cdot n\text{H}_2\text{O}$. 2
- (6)**

3. The oxyanions of chlorine are shown in the table.

Name	Formula	Number of non-bonding electron pairs on the chlorine atom
Chlorate(I)	ClO^-	3
Chlorate(V)	ClO_3^-	x
Chlorate(VII)	ClO_4^-	y

- (a) Draw a diagram for the chlorate(I) ion that clearly shows all of the outer shell electrons of **both** atoms. 1
- (b) Give the values of x and y in the table. 2
- (c) What is the shape of
(i) the chlorate(V) ion,
(ii) the chlorate(VII) ion? 2
- (5)**

4. In the emission spectrum for hydrogen, there are several different series of "spectral lines". The lines result from electrons emitting energy as they fall back from higher to lower energy levels. Each spectral line may be represented by the equation

$$\frac{1}{\lambda} = R_h \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

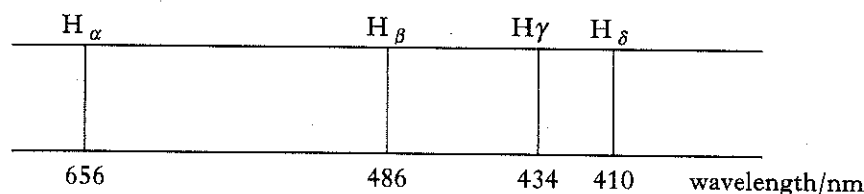
where λ = wavelength of the spectral line

R_h = a constant, $1.097 \times 10^7 \text{ m}^{-1}$

n_1 = energy level to which the electron falls

n_2 = energy level from which the electron falls.

The Balmer series occurs in the visible part of the electromagnetic spectrum, n_1 having a value of 2 for each line in the series. The first four spectral lines for this series are shown in the diagram.



- (a) Use the equation to calculate the wavelength of the spectral line in the Balmer series which corresponds to the value $n_2 = 4$. State the colour of this spectral line. 3
- (b) Lyman discovered a series of spectral lines for hydrogen in the **ultra violet** region of the electromagnetic spectrum. What value must n_1 have for this series? Give a reason for your answer. 2
5. The reduction of nitrobenzene using hydrogen produces phenylamine (aniline). The equation for this reaction is (5)



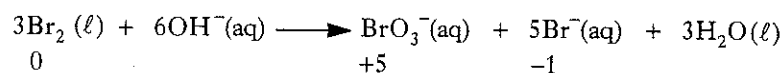
In the laboratory, the hydrogen is generated by the reaction of granulated tin with concentrated hydrochloric acid. The tin reduces the hydrogen ions of the acid and forms a complex ion $[\text{SnCl}_6]^{2-}$. Although phenylamine is a liquid at room temperature, the contents of the reaction flask solidify after the reaction mixture has cooled down. The reason for this is that the amino group of the phenylamine accepts a hydrogen ion from the acid and then combines with the $[\text{SnCl}_6]^{2-}$ ion to form an organic salt.

- (a) Name the complex tin ion $[\text{SnCl}_6]^{2-}$. 1
- (b) (i) Write an equation to show the reaction between a hydrogen ion and phenylamine. 2
(ii) What is the formula of the organic salt? 2
- (c) Name a substance that could be added to the cooled reaction flask to free the phenylamine from the organic salt. 1
- (d) In an experiment, 20 g of nitrobenzene reacts with tin and concentrated hydrochloric acid to form 12 g of phenylamine. Calculate the percentage yield. 3

(7)

[Turn over

6. Bromine reacts with hot alkali as follows.



In this reaction, the bromine exists in different oxidation states, shown under the equation. In a reaction like this where the oxidation number for an element or an ion changes to give two other oxidation numbers (one being higher and the other lower), the reaction is known as disproportionation.

- (a) Study the reaction in which sulphur is precipitated from an acidified solution containing thiosulphate ions.



Determine the three different oxidation numbers for sulphur in this reaction. Show that this is an example of disproportionation.

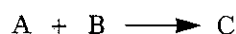
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- (b) White copper(I) sulphate powder disproportionates on adding water. What would **be seen** which would show that two new products had formed?

2

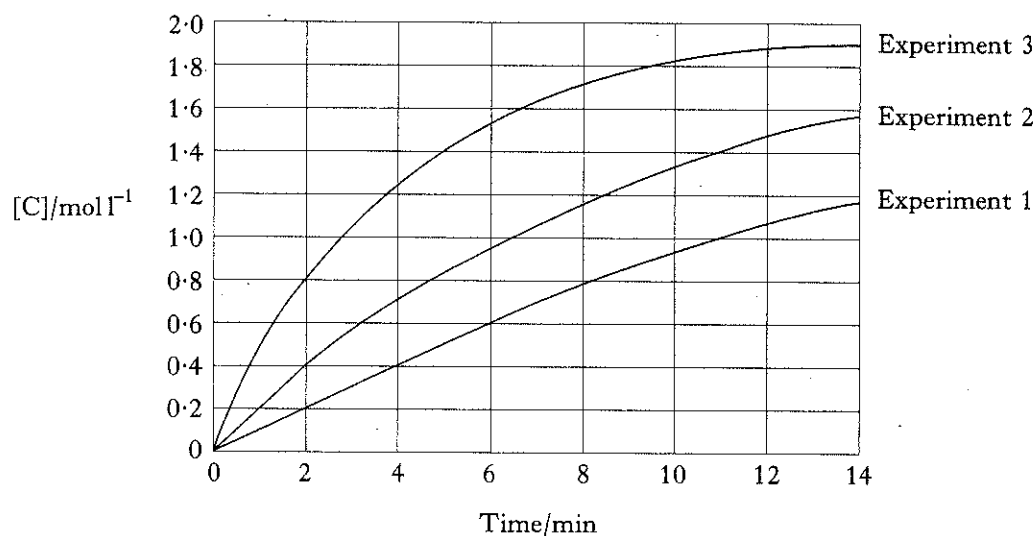
(4)

7. A set of experiments were carried out to investigate the reaction:



The results are shown below.

Experiment	Initial [A]/mol l ⁻¹	Initial [B]/mol l ⁻¹
1	0.1	0.1
2	0.1	0.2
3	0.2	0.1



- (a) Find the average rate of reaction for the first 2 minutes for each experiment.
- (b) Determine the order for A and B and deduce the rate equation for the reaction.
- (c) Calculate the rate constant for the reaction.

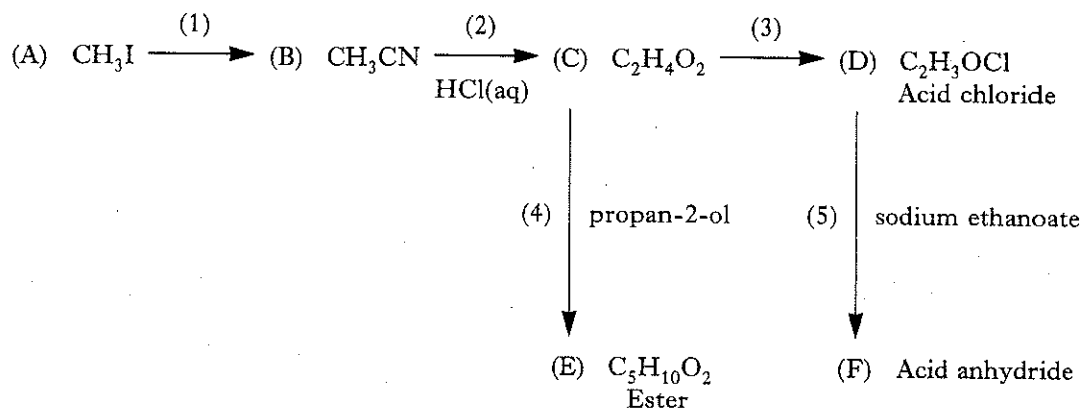
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3

2

(7)

8. Starting from iodomethane, the following reactions could be carried out.



(a) (i) Reaction (1) is an example of a nucleophilic substitution.

What does this mean?

(ii) What nucleophile would be used for this substitution?

2

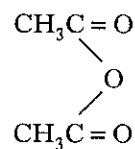
(b) What type of reaction is (2)?

1

(c) Draw the full structural formula for the ester (E).

1

(d) The acid anhydride (F) has the following structure.



Infrared spectra of the anhydride and compound (C) are noticeably different.

Over which wavenumber range would you expect this difference?

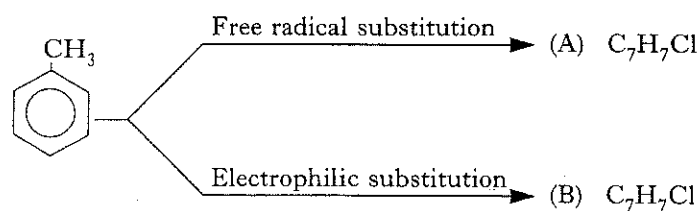
Give a reason for your answer.

2

(6)

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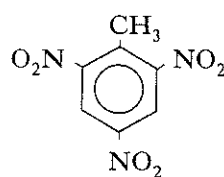
9. Depending on the reaction conditions, toluene can react with chlorine to undergo either
 (i) free radical substitution in the alkyl group
 or (ii) electrophilic substitution in the benzene ring.



Isomers of molecular formula C_7H_7Cl are formed as a result of these reactions.

- (a) Draw the structural formula for each of the isomers (A) and (B), stating the conditions necessary for the chlorine to be able to bring about the substitution reactions.
- (b) State the reagent mixture required to convert toluene into trinitrotoluene.

4

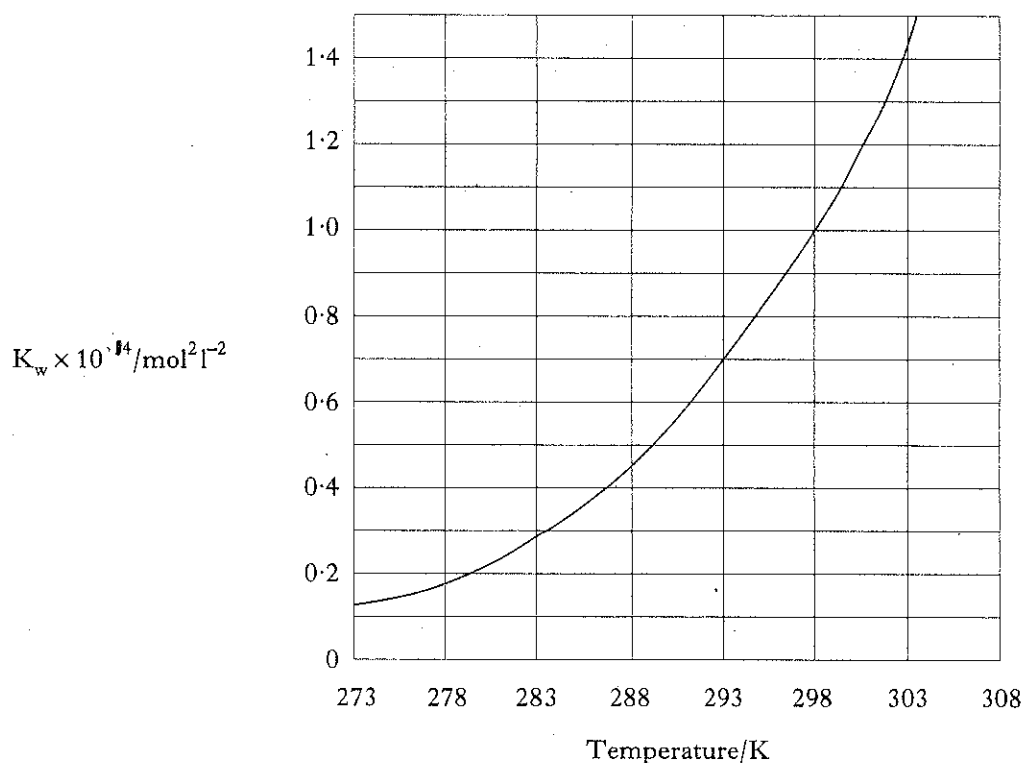


trinitrotoluene

1

(5)

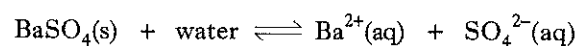
10. At 298K, the dissociation constant, K_w , for water is $1 \times 10^{-14} \text{ mol}^2 \text{ l}^{-2}$. The graph shows the variation of K_w with temperature.



From the graph, calculate the pH of water at 288K.

(3)

11. In the data booklet, the solubility of barium sulphate, shown by the equation



is given as less than 1 g l^{-1} . In a more advanced text book, it is noticed that an equilibrium constant, known as the solubility product K_{sp} , can be written to represent the dissolving process. K_{sp} is equal to the product of the concentrations of the ions in the solution:

$$K_{\text{sp}} = [\text{Ba}^{2+}] \times [\text{SO}_4^{2-}]$$

At 298K, K_{sp} for barium sulphate is equal to $1 \times 10^{-10} \text{ mol}^2 \text{ l}^{-2}$.

For a saturated solution of barium sulphate at 298K, calculate

- (a) the concentration of the barium ions dissolved in the solution,
(b) the mass of barium sulphate dissolved in 1 litre of solution.

1

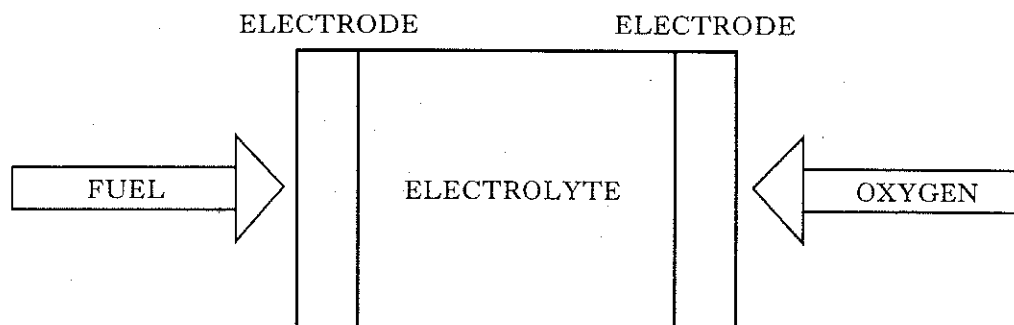
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(4)

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12.

FUEL CELL



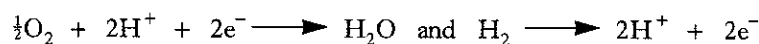
Fuel cells are essentially devices for producing electricity from a combustion reaction. They consist of two electrodes and an electrolyte.

Electrochemical reactions occur at the electrolyte/electrode interface where chemical energy is converted directly into electrical energy. The electrodes catalyse the oxidation of the fuel and the reduction of the oxygen and they also function as interfaces between the reactants and the electrolyte.

Two types of fuel cell being developed for large scale use, which use hydrogen and air as reactants, are described below.

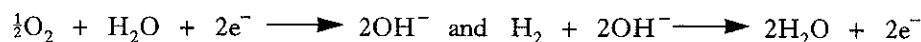
1 The phosphoric acid fuel cell (PAFC)

The electrolyte is 95% phosphoric acid and the electrodes are carbon covered with platinum. The electrode half reactions are:



2 The alkaline fuel cell

The electrolyte is 30–70% potassium hydroxide and electrodes such as nickel, silver and platinum have been tried. The electrode half reactions are:



A serious disadvantage of this cell is that the air must have carbon dioxide removed before use.

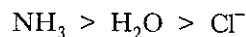
Fuel cells are clean (producing no toxic or corrosive substances) and silent, they contain no moving parts and are easily maintained. However, if fuel cells are to replace conventional power stations to generate electricity, these advantages must outweigh the two main disadvantages, namely

- (i) they are very expensive since the materials used in their manufacture must meet a high specification, and
- (ii) their efficiency is limited by the need to convert from direct to alternating current.

- (a) Give a piece of information found in the passage which suggests that fuel cell reactions are exothermic. 1
- (b) Why must air have carbon dioxide removed from it before use as the oxidant in the alkaline fuel cell? 1
- (c) The overall reaction is common to both cells. Show this by writing the appropriate equation. 1
- (d) In the PAFC, the electrode is carbon covered with platinum. Give a reason for using this type of electrode. 1
- (e) Fuel cells do not cause the pollution problems associated with conventional power generation. Give a specific example to justify this statement. 1

(5)

13. The ability of a ligand to split the d-orbitals when forming a complex ion is given in the "spectrochemical series". Three ligands from this series and their relative ability to split the d-orbitals are shown below.

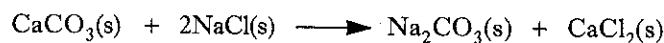


A study of part of the absorption spectrum for the complex ion, hexaaquanickel(II), shows a broad absorption band which peaks at around 410 nm.

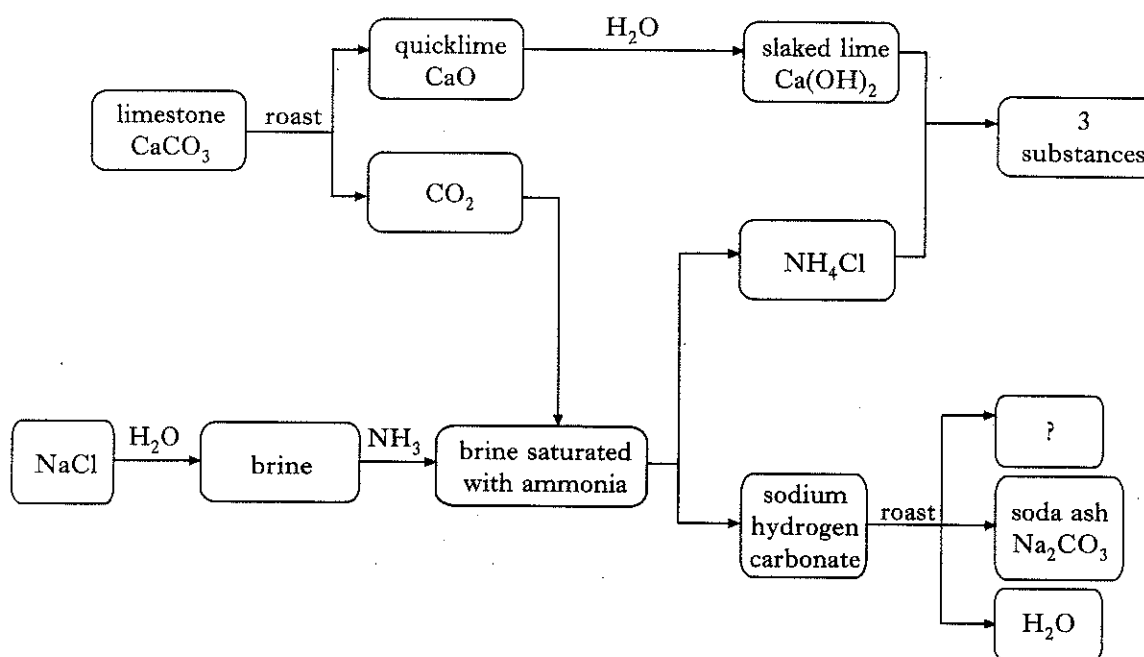
- (a) Explain the origin of the absorption band at this wavelength. 2
- (b) State towards which end of the visible spectrum the wavelength of the absorption band would move if the water ligands were replaced by chloride ions. Give an explanation for your answer. 2

(4)

14. Sodium carbonate (soda ash) is used extensively in the manufacture of glass products. One method of manufacture of soda ash uses the ammonia-soda process. The overall reaction that takes place in this process is



This industrial method has a series of steps, summarised in the diagram below.



- (a) Write balanced equations for the reactions that occur when
- slaked lime and ammonium chloride are added together, and
 - sodium hydrogen carbonate is roasted.
- (b) One of the 3 substances from reaction (a)(i) is recycled in the ammonia-soda process. Name the substance and state where it is used.

2

2

(4)

[END OF QUESTION PAPER]

