

[92/299]

1984

CERTIFICATE OF SIXTH YEAR STUDIES

CHEMISTRY

PAPER

Friday, 11th May—9.30 a.m. to 12.00 noon

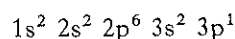


Dalziel High School
Chemistry Department



1984 CSYS

1. What is the charge on the most probable ion from an atom with the electron configuration shown?



- A +1
B -1
C +2
D +3
2. Which quantity of carbon dioxide contains the **least** number of molecules?
- A 10^{23} molecules
B 10 litres at s.t.p.
C 10 g
D 10 moles
3. What type of bonding exists in the element which melts above 3800 K and forms a gaseous oxide?
- A Metallic
B Ionic
C Covalent (non-polar)
D Covalent (polar)
4. 6.5 g zinc and 100 cm³ 1.0 M sulphuric acid gave W cm³ hydrogen.
6.5 g zinc and 150 cm³ 1.0 M sulphuric acid gave X cm³ hydrogen.
9.75 g zinc and 100 cm³ 1.0 M sulphuric acid gave Y cm³ hydrogen.
Which of the following is true?
- A $W = X < Y$
B $W = Y < X$
C $W < X = Y$
D $W = X = Y$

5. $P + 2Q \rightleftharpoons R + S \quad \Delta G^\circ = +10 \text{ kJ mol}^{-1}$

Which of the following **cannot** be deduced from the above information?

The

- A stoichiometry of the reaction
B feasibility of the reaction
C position of equilibrium
D order of the reaction.
6. In which of the following does the transition metal have an oxidation number of +1?
- A $[\text{CoCl}_2(\text{NH}_3)_4]\text{Cl}$
B $\text{K}_5[\text{Mn}(\text{CN})_6]$
C $[\text{Cu}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2]\text{Cl}_2$
D $\text{K}_3[\text{FeF}_6]$
7. Which of the following is a non-linear molecule?
- A CO_2
B C_2H_2
C H_2S
D BeCl_2
8. In the following reaction what change occurs in the three-dimensional arrangement of the bonds round the B atom?
- $$\text{BF}_3 + \text{F}^- \rightarrow \text{BF}_4^-$$
- A Trigonal planar to pyramidal
B Trigonal planar to tetrahedral
C Pyramidal to tetrahedral
D Pyramidal to square planar
9. One mole of calcium chloride contains the Avogadro Constant (Avogadro Number) of
- A positive ions
B positive charges
C negative ions
D negative charges.

10. A reaction **must** be exothermic if
- ΔG is negative
 - ΔS is positive
 - both ΔG and ΔS are negative
 - both ΔG and ΔS are positive.
11. Which of the following is the most powerful oxidising agent?
- $\text{Cl}_2(\text{aq})$
 - $\text{Cl}^-(\text{aq})$
 - $\text{Fe}^{2+}(\text{aq})$
 - $\text{Fe}^{3+}(\text{aq})$
12. $2\text{Cu}^{2+}(\text{aq}) + 4\text{I}^-(\text{aq}) \rightarrow 2\text{CuI}(\text{s}) + \text{I}_2(\text{s})$
 $2\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}_2(\text{s}) \rightarrow \text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{I}^-(\text{aq})$
 50 cm³ 0.02 M CuSO_4 are added to excess KI solution. What volume of 0.1 M $\text{Na}_2\text{S}_2\text{O}_3$ is required to react completely with the liberated iodine?
- 5 cm³
 - 10 cm³
 - 25 cm³
 - 50 cm³
13. Which of the following relates to the fact that each electron in an atom must be distinguishable?
- Hund's Rule of Maximum Multiplicity
 - The Aufbau Principle
 - The Pauli Exclusion Principle
 - Heisenberg's Uncertainty Principle
14. $\text{CuSO}_4(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu}(\text{s})$
 $\Delta H = -210 \text{ kJ mol}^{-1}$
 The heat evolved in kJ when 0.2 mole zinc is added to 300 cm³ 1.0 M CuSO_4 is
- 105
 - 63
 - 42
 - 21
15. When an aluminium atom of mass number 27 is bombarded by alpha particles, a phosphorus atom of mass number 30 is formed. In this process the particle emitted is a
- beta particle
 - hydrogen atom
 - proton
 - neutron.
16. $\text{P} + \text{Q} \rightleftharpoons \text{R} + \text{S}$
 The concentration of R at equilibrium was 0.6 mol l⁻¹. The initial concentrations of P and Q were each 1.0 mol l⁻¹, and those of R and S zero. The value of the equilibrium constant was
- 0.16
 - 0.44
 - 2.25
 - 6.25
17. A small quantity of each of the following is added to separate samples of an aqueous solution of ethanoic acid. Which would lower the concentration of ethanoate ions?
- Dilute sulphuric acid solution
 - Dilute potassium hydroxide solution
 - Magnesium powder
 - Sodium carbonate crystals
18. Which of the following changes would account for a rise in the pH of a solution from 6 to 8?
- Increasing the hydrogen ion concentration ten times
 - Decreasing the hydrogen ion concentration one hundred times
 - Increasing the hydrogen ion concentration by one third
 - Doubling the concentration of the hydroxide ion

[Turn over

19. The lattice energy of a salt is 769 kJ mol^{-1} and its enthalpy of hydration is -765 kJ mol^{-1} .

This salt

- A will not dissolve in water
- B if soluble, will dissolve in water with practically no temperature change
- C has a large negative enthalpy of solution
- D will dissolve in water because of an increase in entropy.

20. For the reaction $A + B \rightarrow C$, the following data were obtained.

Experiment	Initial concentration of A/ mol l^{-1}	Initial concentration of B/ mol l^{-1}	Initial rate of formation of C/ $\text{mol l}^{-1} \text{ s}^{-1}$
1	0.1	0.1	0.03
2	0.1	0.2	0.12
3	0.2	0.2	0.12

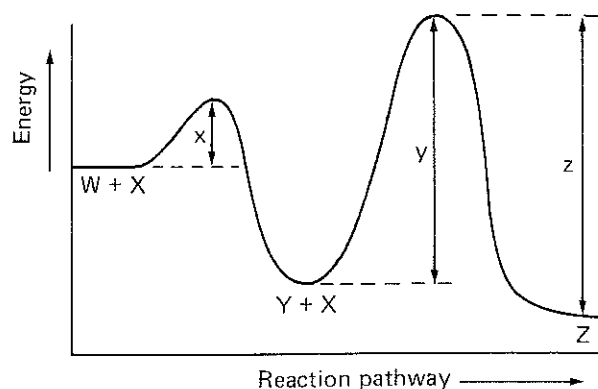
The rate law for this reaction is

- A rate = $k[A][B]$
- B rate = $k[A]^2$
- C rate = $k[A]^2[B]$
- D rate = $k[B]^2$.

21. A reaction in dynamic equilibrium is one in which

- A ΔG° is always zero
- B ΔG is always zero
- C activation energy of the forward reaction = activation energy of the reverse reaction
- D ΔH for the forward reaction = ΔH for the reverse reaction.

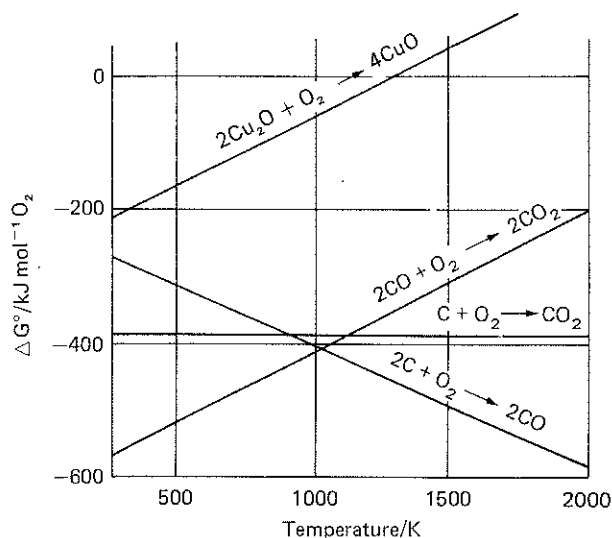
22. In a multistage reaction $W + 2X \rightarrow Z$ which involves an intermediate Y, the energy diagram is as follows.



Which of the following statements is correct?

- A The rate of the reaction = $k[W][X]$.
- B The activation energy for the overall reaction is $(y + x)$.
- C The reaction overall is endothermic.
- D The rate determining step is $Y + X \rightarrow Z$.

Questions 23 and 24 refer to the following graph.



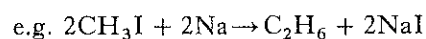
23. Which reaction is more feasible at 1500 K than the formation of carbon dioxide from its elements?

- A $2\text{Cu}_2\text{O} + \text{O}_2 \rightarrow 4\text{CuO}$
 B $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$
 C $2\text{C} + 2\text{O}_2 \rightarrow 2\text{CO}_2$
 D $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$

24. The main reason for the almost constant value of ΔG° at different temperatures for the reaction $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ is that for the reaction

- A ΔS° is almost zero
 B ΔS° is approximately equal to ΔH°
 C ΔH° is almost zero
 D both ΔS° and ΔH° are almost zero.

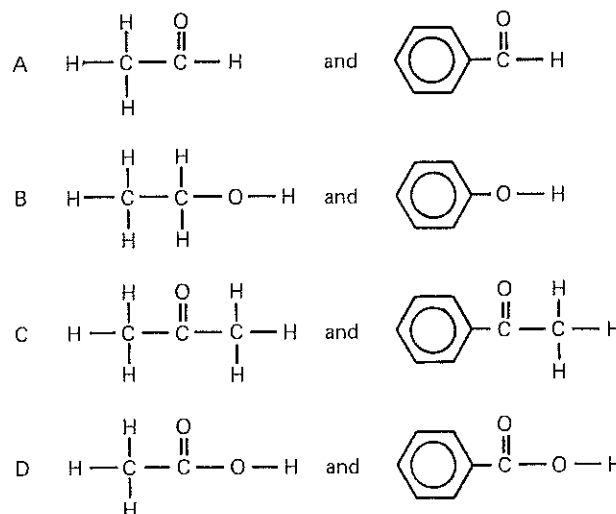
25. Some alkanes may be prepared by adding an alkyl iodide dropwise to a suspension of sodium in a suitable solvent.



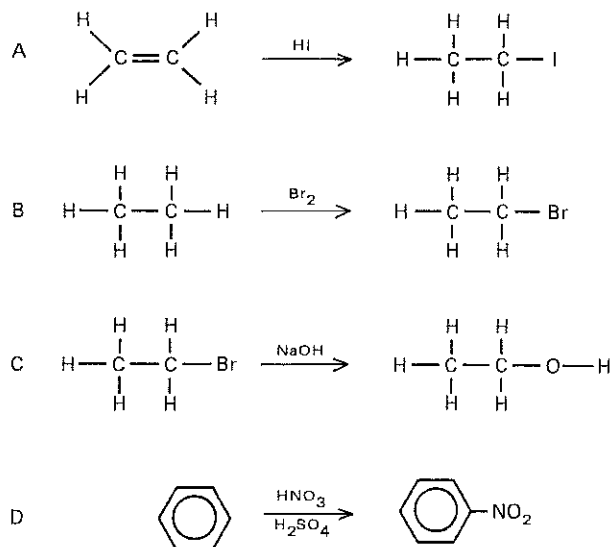
When a mixture of iodomethane and iodoethane is used as starting material, the product will contain

- A propane only
 B methane and ethane
 C ethane, propane and butane
 D methane, ethane, propane and butane.

26. Which pair of compounds shows the biggest difference in chemical properties?



Questions 27 and 28 refer to the following reactions.

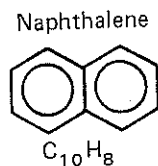


Note: A reaction may be used more than once.

27. In which of the above does the organic compound undergo substitution by an electrophilic species?

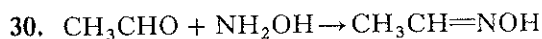
28. In which of the above does the attacking reagent undergo homolytic fission?

29.



What volume of hydrogen (measured at s.t.p.), would be required for the complete hydrogenation of 12.8 g naphthalene?

- A 6.72 l
- B 8.92 l
- C 11.20 l
- D 13.40 l



This reaction is an example of

- A hydrolysis
- B hydration
- C reduction
- D condensation.

31. In the homologous series of alkanols, increase in chain length from CH_3OH to $C_{20}H_{41}OH$ is accompanied by

- A increased volatility and increased solubility in water
- B increased volatility and decreased solubility in water
- C decreased volatility and decreased solubility in water
- D decreased volatility and increased solubility in water.

32. Which of the following is most reactive as a nucleophile?

- A NH_3
- B NH_4^+
- C Br_2
- D CH_3I

Questions 33 and 34 refer to the following steps which are used during the extraction of metals from their naturally occurring compounds.

- A zinc sulphide \rightarrow zinc oxide
- B titanium oxide \rightarrow titanium chloride
- C magnesium carbonate \rightarrow
magnesium chloride
- D aluminium oxide \rightarrow sodium aluminate

Note: A step may be used more than once.

33. Which is used to separate the required metal from unwanted impurities?

34. Which is followed by reaction with another metal to displace the required metal?

35. The Fischer-Tropsch synthesis of hydrocarbons uses carbon monoxide and hydrogen over a mixture of the oxides of thorium and cobalt. The same gases passed over zinc oxide results in the formation of methanol. This is because

- A the zinc oxide is a more powerful oxidising agent than the other metal oxides used
- B the mixture of metal oxides has a higher degree of entropy which favours the formation of hydrocarbons
- C the high thermal stability of thorium and cobalt oxides prevents further oxidation of the hydrocarbons
- D surface catalysts are often highly specific in their reactions.

36. Which solid would you expect to yield a colourless solution?

- A $K_2Cr_2O_7$
- B $KMnO_4$
- C K_2SeO_4
- D $CrCl_3$

37. The colour change from light blue to dark blue when excess ammonia is added to copper(II) sulphate solution is due to

- A a change in the oxidation state of copper
- B the removal of the degeneracy of the d-orbitals
- C an alteration in the ligand field strength
- D a change from octahedral to tetrahedral coordination.

To answer Questions 38 to 40 use the following code.


If all the responses 1, 2 and 3 are correct, select A.

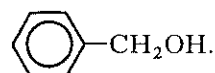
If only 1 and 2 are correct, select B.

If only 3 is correct, select C.

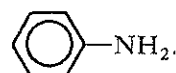
Otherwise select D.

38. Which are true statements?

1 -OH is a stronger acid than



2 C₂H₅NH₂ is a stronger base than

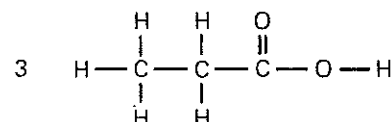
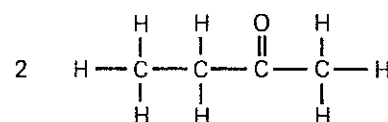
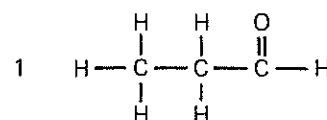


3 C₂H₅CONH₂ is a stronger base than C₂H₅NH₂.

39. The energy associated with electromagnetic radiation is directly proportional to the

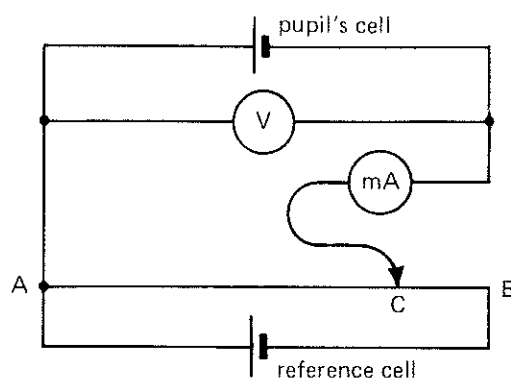
- 1 velocity of the radiation
- 2 reciprocal of the wavenumber of the radiation
- 3 reciprocal of the wavelength of the radiation.

40. Which of the following will form a derivative with 2,4-dinitrophenylhydrazine?



[END OF QUESTION PAPER]

1. A pupil constructed a cell which involved the oxidation of copper metal by chlorine gas. The cell was then incorporated into the following circuit.



The following results were obtained as the moveable contact, C, was moved along the wire AB.

Current Reading /mA	Voltage /V
185	0.78
0	0.95
-40	1.15
-106	1.41
-210	1.92

- (a) What is the e.m.f. of the cell from the pupil's results?
Explain your answer. 2
- (b) Write the ion-electron half equations for the reactions at each electrode when the pupil's cell is providing electricity. 1
- (c) Use the information on page 6 of the Data Booklet to calculate the standard e.m.f. for this cell. 1
- (d) Suggest why the calculated cell e.m.f. differs from the experimentally observed value. 1
- (e) Calculate the standard free energy change for the oxidation of copper by chlorine. 2
- (7)

2. Answer EITHER A OR B.

A. Haematite, a naturally occurring iron ore, consists mainly of an oxide of iron.

In an experiment 4.10 g of the ore were dissolved in concentrated hydrochloric acid and the solution diluted with water to 250 cm³. Aqueous ammonia was added to 50 cm³ of this solution and the resulting precipitate of iron(III) hydroxide was filtered, washed and heated strongly. The product was iron(III) oxide and it weighed 0.73 g.

- (a) Calculate the mass of iron in the iron(III) oxide. 1
- (b) Calculate the mass of iron in the original sample. 1
- (c) Calculate the formula of haematite given that the ore is 90% iron oxide. 3
- (d) Write a balanced equation for the conversion of iron(III) hydroxide to iron(III) oxide. 1
- (e) The mass of iron(III) oxide obtained at the end of this experiment is sometimes greater than that expected. 1
- Suggest a reason for this difference. 1
- (7)**

OR

B. In aqueous acidic solution, potassium iodate (KIO₃) oxidises titanium(III) chloride to titanium(IV) chloride and is itself reduced to potassium iodide.

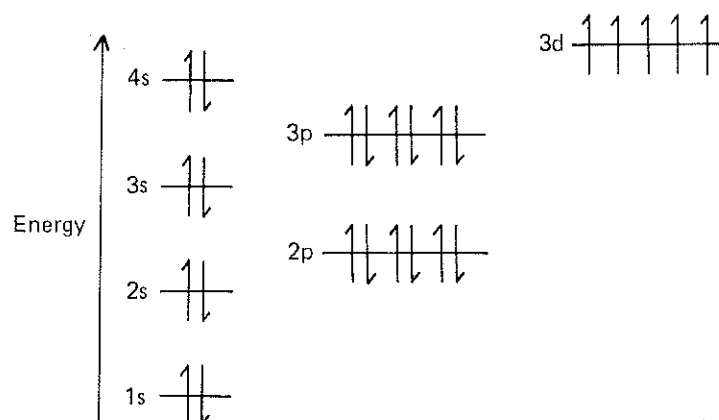
[It is assumed that these chlorides exist in the ionic form.]

In an experiment, 4.6 g of titanium(III) chloride were dissolved in hydrochloric acid and the resulting solution made up to 250 cm³. A 25 cm³ portion of this solution required 20 cm³ of a 0.02 M potassium iodate solution for its complete oxidation.

- (a) Write ion-electron half equations for the conversion of
- (i) titanium(III) to titanium(IV), and
- (ii) iodate to iodide. 2
- (b) Calculate the number of moles of iodate ions in the iodate solution used in the experiment. 1
- (c) How many moles of titanium(III) ions were present in the 250 cm³ sample? 1
- (d) Calculate the percentage purity of the titanium(III) chloride. 2
- (e) Suggest why hydrochloric acid is a better choice than nitric acid to acidify the original solution. 1
- (7)**

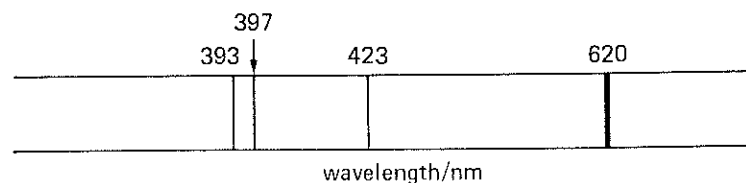
[Turn over

3. The electron configuration of an atom of element Y in the ground state can be represented as



- (a) Identify element Y. 1
 - (b) The electron configuration of an atom or ion may also be expressed in another form, e.g. $1s^2 2s^2 2p^1$ for boron. 1
Give the electron configuration for Y in this form. 1
 - (c) Give the electron configuration of the ion Y^{3+} . 1
- (3)**

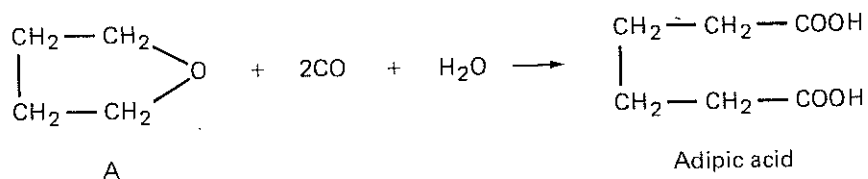
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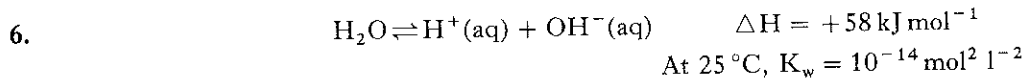
The diagram represents part of the emission spectrum of a metal.

- (a) Which line corresponds to the highest energy electron transition? 2
Give a reason for your answer. 1
 - (b) In what way would an absorption spectrum of the metal differ in appearance from the above? 1
 - (c) Calculate the wavenumber (in cm^{-1}) of the 620 nm line. 2
 - (d) What colour would be observed if a salt of this metal were placed in a bunsen flame? 1
- (6)**

5. Adipic acid can be made industrially by the following process.



- (a) To what class of organic compounds does A belong? 1
- (b) Suggest possible safety hazards which could be encountered in this process. 2
- (c) Write the structure of a compound which could be reacted with adipic acid to form a polyester. 1
- (d) Draw part of the polyester chain between adipic acid and the compound you have chosen in (c). Show two linkages. 1
- (e) Adipic anhydride is obtained when adipic acid is heated. Draw the structural formula of adipic anhydride. 1
- (6)**



Discuss briefly the effect of temperature on the value of K_w . (2)

[Turn over

7. Answer EITHER A OR B.

A. A pupil added 30 cm^3 of 2.0 M sodium hydroxide to 40 cm^3 of 1.0 M sulphuric acid.

(a) Calculate the number of moles of

(i) the alkali and of the acid before mixing, and

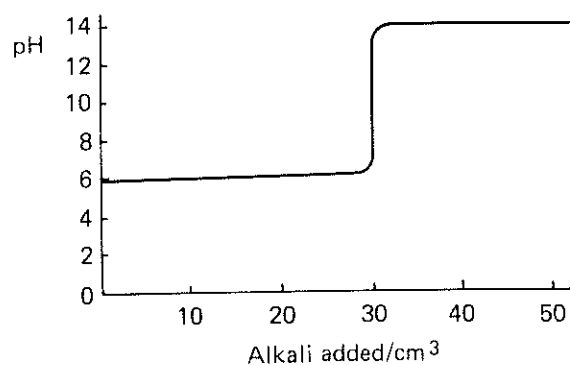
(ii) the excess reactant left after addition of alkali to acid.

(b) Calculate the pH of the resultant solution.

1
2
3
(6)

OR

B.



Indicator	pH range
phenolphthalein	8.5–10.2
bromothymol blue	6.0–7.8
methyl orange	3.0–4.6

The graph shows the pH changes when 2.0 M sodium hydroxide solution was added to 20 cm^3 of an acid solution.

The table shows the pH ranges over which certain indicators change colour.

The acid involved was either chlorous acid, HClO_2 , ($K_a = 1.1 \times 10^{-2}$) or chloric acid, HClO_3 , ($K_a = 1 \times 10^{-3}$).

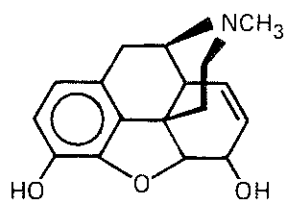
(a) Which acid was involved? Give a reason for your answer.

(b) Which indicator should be used in the titration? Give a reason for your answer.

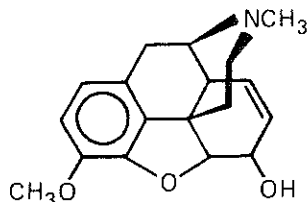
(c) Calculate the molarity of the acid used.

2
2
2
(6)

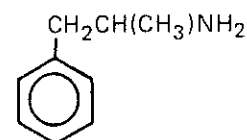
8. Look carefully at the structures of the drugs shown below. Drug companies often try to synthesise new compounds which are derived from, or are similar to, known active drugs. This is because many drugs which act in a similar way have similar structures.



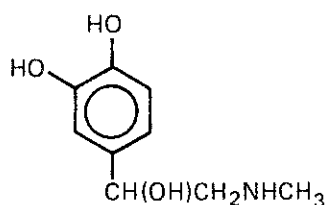
morphine



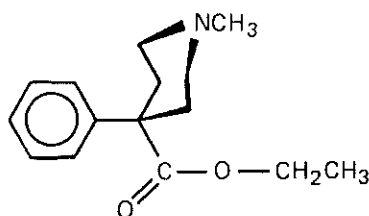
codeine



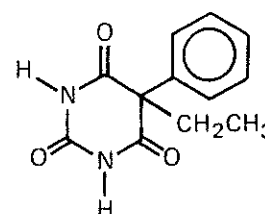
amphetamine



adrenaline



pethidine



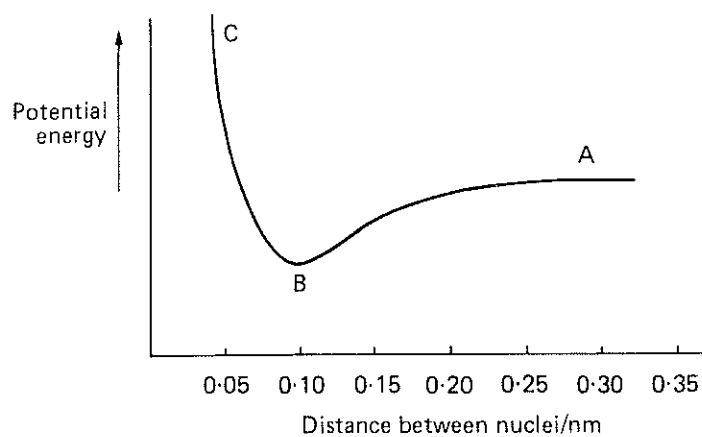
phenobarbitone

- (a) Which drug contains an ester group? 1
- (b) Adrenaline is a compound produced by the body which prepares it for extra physical activity under stress conditions.
Suggest why amphetamines are used in "pep" pills. 2
- (c) Morphine and codeine are obtained from the opium poppy. They are used to relieve pain but both are addictive. Another potent analgesic (pain reliever) was synthesised in 1939.
(i) Which of the drugs shown is this synthetic analgesic? Justify your choice. 3
(ii) Suggest an advantage which the company hoped the synthetic analgesic would have over morphine and codeine. 1
- (d) Derivatives of these drugs can be made using nitration as the first stage.
What do they all have in common which enables them to be nitrated? 1

(8)

[Turn over

9. The diagram below relates to the formation of a hydrogen molecule as two isolated hydrogen atoms approach each other.



- (a) Describe what is happening in terms of electrostatic attractions and repulsions,
- (i) between A and B,
 - (ii) at B,
 - (iii) between B and C.
- (b) What is the name given to the energy difference between B and A?

4

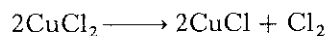
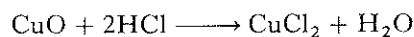
1

(5)

10. Answer EITHER A OR B.

A. In the Deacon Process for the conversion of hydrogen chloride to chlorine, copper(II) oxide is used to catalyse the reaction.

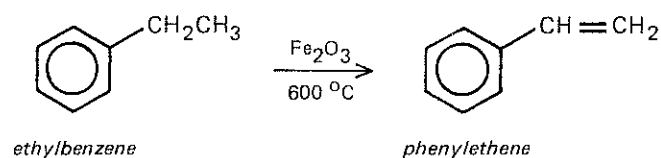
A suggested mechanism for the reaction is



- (a) Write the overall stoichiometric equation for the reaction. 1
- (b) Why can copper(II) oxide be regarded as a catalyst for the reaction? 1
- (c) What property of copper, other than catalytic action, is being demonstrated here? 1
- (d) In the laboratory potassium manganate(VII) is often used to produce chlorine from hydrochloric acid. Suggest why this is not used industrially. 1
- (4)

OR

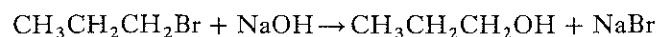
B. The unsaturated aromatic hydrocarbon, phenylethene, can be made industrially as shown:



- (a) What kind of reaction is this? 1
- (b) The iron(III) oxide is dispersed and supported on aluminium oxide. Suggest a reason for this. 1
- (c) Suggest a possible industrial use for phenylethene. 1
- (d) Give a possible structure for the hydrocarbon formed when ethylbenzene reacts with chloroethane in the presence of aluminium chloride. 1
- (4)

[Turn over

11. The stoichiometric equation for the reaction between 1-bromopropane and sodium hydroxide is

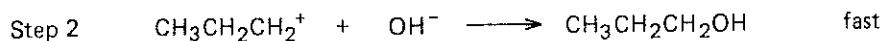
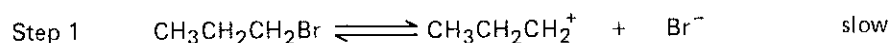


The following data were obtained in a series of five experiments:

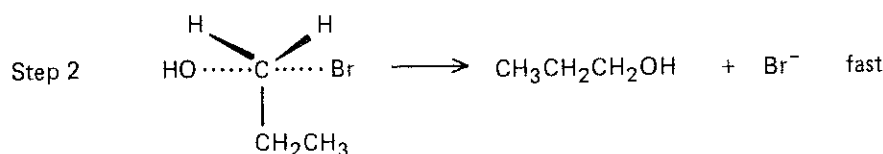
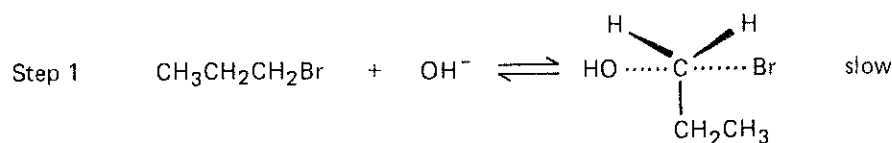
Experiment Number	Concentration of 1-bromopropane /mol l ⁻¹	Concentration of sodium hydroxide /mol l ⁻¹	Rate of production of propan-1-ol /mol l ⁻¹ s ⁻¹
1	0.5	0.1	5.5 × 10 ⁻⁶
2	1.0	0.1	1.3 × 10 ⁻⁵
3	2.0	0.1	2.7 × 10 ⁻⁵
4	0.5	0.2	1.2 × 10 ⁻⁵
5	0.5	0.4	2.5 × 10 ⁻⁵

- (a) What is the order of this reaction with respect to
 (i) the alkyl halide;
 (ii) the sodium hydroxide? 2
- (b) Write down the rate equation for the overall reaction. 1
- (c) What are the units of the rate constant? 1
- (d) Use the results from experiment 1 to calculate the rate constant for the reaction. 1
- (e) Two mechanisms for this reaction have been proposed.

Mechanism A



Mechanism B



Which of these mechanisms is the more likely? Explain your reasoning clearly.

3
(8)

12. Three compounds can result from the reaction between copper(II) chloride and ammonia. These compounds were reacted with silver(I) nitrate solution and the number of moles of silver(I) chloride formed per mole of each compound was calculated.

<i>Compound</i>	<i>Empirical Formula</i>	<i>Moles of silver(I) chloride</i>
1	$\text{CuCl}_2 \cdot 4\text{NH}_3$	2
2	$\text{CuCl}_2 \cdot 3\text{NH}_3$	1
3	$\text{CuCl}_2 \cdot 2\text{NH}_3$	0

- (a) Using the above, give the formula of the complex ion present in each compound. State reasons for your answers. 4
- (b) Suggest why these three compounds have different colours from aqueous copper(II) salts. 2

(6)

13. Write an essay on **ONE** of the following topics. Each topic has suggestions which may help you to answer the question but there is no need to use them unless you so wish. The Data Booklet may be a useful additional source of information.

The essay will be assessed for scientific content, organisation, presentation and English usage.

A Cyclic Compounds in Organic Chemistry.

(Structure, bonding, properties and reactions of cycloalkanes and benzene.)

OR

B Extraction of Metals.

(Nature of ores, extraction techniques and choice of technique, thermodynamic, kinetic and economic factors.)

OR

C Modern Atomic Theory.

(How and why the chemist now regards the structure of an atom, evidence and applications.)

(12)

[END OF QUESTION PAPER]