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| Surname | | | | | | Other Names | | | | | |
| Centre Number | | | | | | Candidate Number | | | | | |
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General Certificate of Education
June 2006
Advanced Level Examination



CHEMISTRY
Unit 6a Synoptic Assessment

CHM6/W

Monday 26 June 2006 9.00 am to 10.00 am

For this paper you must have:

- an objective test answer sheet,
- a calculator.

Time allowed: 1 hour

Instructions

- Use a black ball-point pen. Do **not** use pencil.
- Fill in the boxes at the top of this page.
- Answer **all** 40 questions.
- For each item there are four responses. When you have selected the response which you think is the best answer to a question, mark this response on your answer sheet.
- Mark all responses as instructed on your answer sheet. If you wish to change your answer to a question, follow the instructions on your answer sheet.
- Do all rough work in this book, **not** on your answer sheet.
- Make sure that you hand in **both** your answer sheet **and** this answer book at the end of this examination.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information

- Each correct answer will score one mark. No deductions will be made for wrong answers.
- Graph paper is available from the Invigilator.

Advice

- Do not spend too long on any question. If you have time at the end, go back and answer any question you missed out.

There are no questions printed on this page

The Periodic Table of the Elements

- The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

| | | I | II | III | IV | V | VI | VII | 0 | | | | | | | | | | | | | | | | |
|-------|-----------------------------|--------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|--|--|---------------------------------------|--|---------------------------------------|--------------------------------------|--|---|---|--------------------------------------|--|---------------------------------------|---|
| 1.0 | H Hydrogen | | | | | | | | 4.0 He Helium 2 | | | | | | | | | | | | | | | | |
| 6.9 | Li Lithium 3 | 9.0 Be Beryllium 4 | 6.9 Li Lithium 3 | | 10.8 B Boron 5 | 12.0 C Carbon 6 | 14.0 N Nitrogen 7 | 16.0 O Oxygen 8 | 19.0 F Fluorine 9 | 20.2 Ne Neon 10 | | | | | | | | | | | | | | | |
| 23.0 | Na Sodium 11 | 24.3 Mg Magnesium 12 | 23.0 Na Sodium 11 | | 27.0 Al Aluminium 13 | 28.1 Si Silicon 14 | 31.0 P Phosphorus 15 | 32.1 S Sulphur 16 | 35.5 Cl Chlorine 17 | 39.9 Ar Argon 18 | | | | | | | | | | | | | | | |
| 39.1 | K Potassium 19 | 40.1 Ca Calcium 20 | 54.9 Mn Manganese 25 | 55.8 Fe Iron 26 | 58.9 Co Cobalt 27 | 58.7 Ni Nickel 28 | 63.5 Cu Copper 29 | 65.4 Zn Zinc 30 | 69.7 Ga Gallium 31 | 72.6 Ge Germanium 32 | 74.9 As Arsenic 33 | 79.0 Se Selenium 34 | 79.9 Br Bromine 35 | 83.8 Kr Krypton 36 | | | | | | | | | | | |
| 85.5 | Rb Rubidium 37 | 87.6 Sr Strontium 38 | 98.9 Tc Technetium 43 | 101.1 Ru Ruthenium 44 | 102.9 Rh Rhodium 45 | 106.4 Pd Palladium 46 | 107.9 Ag Silver 47 | 112.4 Cd Cadmium 48 | 114.8 In Indium 49 | 118.7 Sn Tin 50 | 121.8 Sb Antimony 51 | 127.6 Te Tellurium 52 | 126.9 I Iodine 53 | 131.3 Xe Xenon 54 | | | | | | | | | | | |
| 132.9 | Cs Caesium 55 | 137.3 Ba Barium 56 | 186.2 Re Rhenium 75 | 190.2 Os Osmium 76 | 192.2 Ir Iridium 77 | 195.1 Pt Platinum 78 | 197.0 Au Gold 79 | 200.6 Hg Mercury 80 | 204.4 Tl Thallium 81 | 207.2 Pb Lead 82 | 209.0 Bi Bismuth 83 | 210.0 Po Polonium 84 | 210.0 At Astatine 85 | 222.0 Rn Radon 86 | | | | | | | | | | | |
| 223.0 | Fr Francium 87 | 226.0 Ra Radium 88 | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | 88 – 71 Lanthanides | | 140.1 Ce Cerium 58 | | 140.9 Pr Praseodymium 59 | 144.2 Nd Neodymium 60 | 144.9 Pm Promethium 61 | 150.4 Sm Samarium 62 | 152.0 Eu Europium 63 | 157.3 Gd Gadolinium 64 | 162.5 Dy Dysprosium 66 | 164.9 Ho Holmium 67 | 167.3 Er Erbium 68 | 168.9 Tm Thulium 69 | 173.0 Yb Ytterbium 70 | 175.0 Lu Lutetium 71 |
| | | | | | | | | | | 89 – 103 Actinides | | 232.0 Th Thorium 90 | 231.0 Pa Protactinium 91 | 238.0 U Uranium 92 | 237.0 Np Neptunium 93 | 239.1 Pu Plutonium 94 | 243.1 Am Americium 95 | 247.1 Cm Curium 96 | 247.1 Bk Berkelium 97 | 252.1 Cf Californium 98 | (252) Es Einsteinium 99 | (257) Fm Fermium 100 | (258) Md Mendelevium 101 | (259) No Nobelium 102 | (260) Lr Lawrencium 103 |

Gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Table 1
Proton n.m.r chemical shift data

| Type of proton | δ/ppm |
|-------------------------|---------------------|
| RCH_3 | 0.7–1.2 |
| R_2CH_2 | 1.2–1.4 |
| R_3CH | 1.4–1.6 |
| RCOCH_3 | 2.1–2.6 |
| ROCH_3 | 3.1–3.9 |
| RCOOCH_3 | 3.7–4.1 |
| ROH | 0.5–5.0 |

Table 2
Infra-red absorption data

| Bond | Wavenumber/ cm^{-1} |
|-------------------------|------------------------------|
| C—H | 2850–3300 |
| C—C | 750–1100 |
| C=C | 1620–1680 |
| C=O | 1680–1750 |
| C—O | 1000–1300 |
| O—H (alcohols) | 3230–3550 |
| O—H (acids) | 2500–3000 |

Multiple choice questions

Each of Questions 1 to 21 consists of a question or an incomplete statement followed by four suggested answers or completions. You are asked to select the most appropriate answer in each case.

1 Which one of the following is the electron arrangement of the strongest reducing agent?

- A $1s^2 2s^2 2p^5$
 B $1s^2 2s^2 2p^6 3s^2$
 C $1s^2 2s^2 2p^6 3s^2 3p^5$
 D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

2 The table below shows data for the four hydrocarbons ethyne, propyne, propene and propane. ΔH_c^\ominus is the standard enthalpy of combustion of these hydrocarbons.

| Compound | Name | M_r | $-\Delta H_c^\ominus/\text{kJ mol}^{-1}$ |
|-------------------------------------|---------|-------|--|
| $\text{HC}\equiv\text{CH}$ | ethyne | 26 | 1300 |
| $\text{HC}\equiv\text{CCH}_3$ | propyne | 40 | 1940 |
| $\text{H}_2\text{C}=\text{CHCH}_3$ | propene | 42 | 2060 |
| $\text{CH}_3\text{CH}_2\text{CH}_3$ | propane | 44 | 2220 |

The complete combustion of 2.0 g of one of the above hydrocarbons releases exactly 100 kJ of heat energy.

This hydrocarbon is

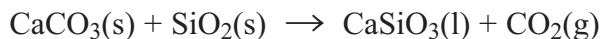
- A ethyne
 B propyne
 C propene
 D propane

3 Which one of the equations below represents a reaction that is feasible at all temperatures?

- A $\text{P(s)} \rightarrow \text{Q(s)} + \text{R(g)}$ endothermic
 B $2\text{L(g)} + \text{M(g)} \rightarrow 2\text{N(g)}$ exothermic
 C $\text{S(g)} \rightarrow 2\text{T(g)}$ exothermic
 D $\text{A(g)} + \text{B(g)} \rightarrow \text{C(g)}$ endothermic

Questions 4 to 6

The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

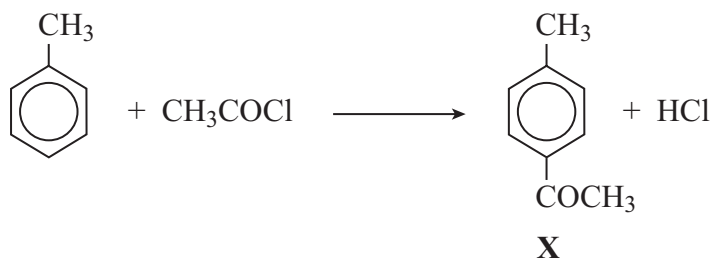


- 4 Which one of the following statements is **not** correct?
- A There is an increase in entropy during this reaction.
 - B The calcium silicate formed floats on the surface of the molten iron.
 - C The calcium silicate formed can be used in the construction industry.
 - D Silicon dioxide is a basic oxide.
- 5 The minimum mass of calcium carbonate needed to remove 1.00 tonne (1000 kg) of silicon dioxide is
- A 0.46 tonne
 - B 0.60 tonne
 - C 1.67 tonne
 - D 2.18 tonne
- 6 The volume of carbon dioxide, measured at 298 K and 1.01×10^5 Pa, formed in this reaction during the removal of 1.00 tonne (1000 kg) of silicon dioxide is
- A 24.5 dm³
 - B 408 dm³
 - C 24.5 m³
 - D 408 m³

- 7 In which one of the following species is the shape influenced by the presence of one or more lone pairs of electrons?
- A NH_2^-
- B NH_4^+
- C $[\text{CH}_3\text{NH}_3]^+$
- D $[\text{Co}(\text{NH}_3)_6]^{2+}$
- 8 Which one of the following statements is **not** correct?
- A In the production of steel, sulphur impurities are removed by reaction with magnesium.
- B The equation $\text{VO}_3^- + 2\text{H}^+ \rightarrow \text{VO}_2^+ + \text{H}_2\text{O}$ represents a redox reaction.
- C If an aqueous solution of chlorine is added to aqueous potassium iodide, iodine is formed.
- D The first ionisation energy of sulphur is lower than that of phosphorus because there is repulsion between paired electrons in the 3p sub-level.
- 9 Which one of the following statements is **not** correct?
- A The atomic radii of Period 3 elements decrease from sodium to chlorine.
- B The hydroxides of Group II metals increase in solubility as the group is descended.
- C In water, aluminium chloride is hydrolysed more than magnesium chloride.
- D SiO_2 has a higher melting point than P_4O_{10} because of stronger van der Waals' forces.
- 10 Which one of the following is **not** a redox reaction?
- A $\text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{Br}^-$
- B $\text{SnCl}_2 + \text{HgCl}_2 \rightarrow \text{Hg} + \text{SnCl}_4$
- C $\text{Cu}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{Cu} + \text{H}_2\text{O}$
- D $2\text{CrO}_4^{2-} + 2\text{H}^+ \rightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$

- 11 Which one of the following reactions in aqueous solution has the most positive change in entropy?
- A $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$
- B $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$
- C $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + \text{EDTA}^{4-} \rightarrow [\text{Cu}(\text{EDTA})]^{2-} + 6\text{H}_2\text{O}$
- D $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Cu}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$
- 12 The standard enthalpy of formation, ΔH_f^\ominus for $\text{O}_3(\text{g})$ is $+142 \text{ kJ mol}^{-1}$. In which one of the following would both the changes shown increase the amount of O_2 gas in an equilibrium mixture containing only $\text{O}_2(\text{g})$ and $\text{O}_3(\text{g})$?
- A increasing the temperature and increasing the pressure
- B increasing the temperature and decreasing the pressure
- C decreasing the temperature and increasing the pressure
- D decreasing the temperature and decreasing the pressure
- 13 Which one of the following processes is carried out for environmental reasons only?
- A the fermentation of glucose
- B the recycling of aluminium
- C the catalytic reduction of nitrogen monoxide
- D the combustion of methane
- 14 In which one of the following reactions is a heterogeneous catalyst **not** used?
- A $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
- B $\text{CO} + \text{NO} \rightarrow \text{CO}_2 + \frac{1}{2}\text{N}_2$
- C $\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$
- D $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3$

- 15 Which one of the following can exhibit both geometrical and optical isomerism?
- A $(\text{CH}_3)_2\text{C}=\text{CHCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- B $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- C $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_2\text{CH}_3)_2$
- D $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{C}=\text{CH}_2$
- 16 How many different alkenes are formed when 2-bromo-3-methylbutane reacts with ethanolic potassium hydroxide?
- A 2
- B 3
- C 4
- D 5
- 17 Ethanoyl chloride reacts with methylbenzene forming compound X according to the equation below.



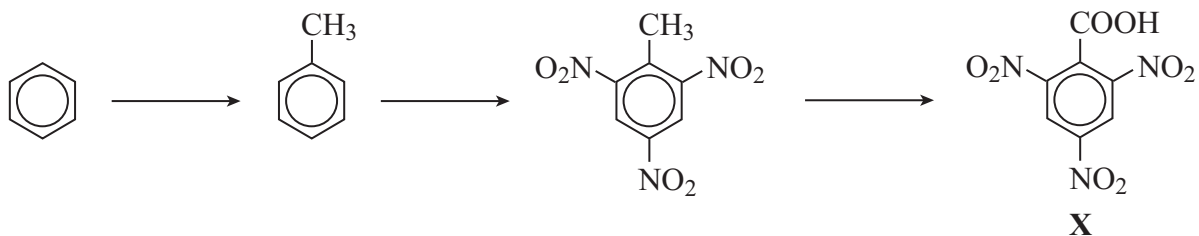
If the experimental yield is 40.0%, the mass in grams of X ($M_r = 134.0$) formed from 18.4 g of methylbenzene ($M_r = 92.0$) is

- A 26.8
- B 16.1
- C 10.7
- D 7.4

- 18** Which one of the following statements explains best why fluoroalkanes are the least reactive haloalkanes?
- A** Fluorine is much more electronegative than carbon.
 - B** The F^- ion is the most stable halide ion.
 - C** The C–F bond is the most polar carbon–halogen bond.
 - D** The C–F bond is the strongest carbon–halogen bond.
- 19** Which one of the following pairs of reagents reacts to form an organic product that shows only 2 peaks in its proton n.m.r. spectrum?
- A** butan-2-ol and acidified potassium dichromate(VI)
 - B** ethanoyl chloride and methanol
 - C** propanoic acid and ethanol in the presence of concentrated sulphuric acid
 - D** ethene and hydrogen in the presence of nickel

Questions 20 and 21

Questions 20 and 21 are based on the reactions and compounds shown in the scheme below.



- 20 Which one of the following types of reaction is **not** shown in the reaction scheme?
- A reduction
 - B oxidation
 - C alkylation
 - D nitration
- 21 A $0.100 \text{ mol dm}^{-3}$ solution of X is found to have a pH of 2.50. The value of K_a in mol dm^{-3} is
- A 3.16×10^{-2}
 - B 3.16×10^{-3}
 - C 1.00×10^{-4}
 - D 1.00×10^{-5}

Multiple completion questions

For each of Questions 22 to 40, **one or more** of the options given may be correct. Select your answer by means of the following code.

A if 1, 2 and 3 only are correct.

B if 1 and 3 only are correct.

C if 2 and 4 only are correct.

D if 4 only is correct.

| Directions summarised | | | |
|-------------------------|----------------------|----------------------|----------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

- 22 The value of the standard enthalpy of formation, ΔH_f^\ominus , for nitrogen monoxide, NO(g), is +90 kJ mol⁻¹.

Which of the following changes would favour the formation of nitrogen monoxide gas in an equilibrium mixture containing nitrogen monoxide, nitrogen and oxygen?

- 1 increasing the temperature
- 2 decreasing the pressure
- 3 adding nitrogen gas to the mixture
- 4 adding a catalyst to the mixture

- 23 Molecules with a permanent dipole include

- 1 NH₃
- 2 PCl₃
- 3 SCl₂
- 4 SiCl₄

| Directions summarised | | | |
|----------------------------|-------------------------|-------------------------|-------------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

- 24 The following information concerns the gas-phase reaction of nitrogen monoxide with hydrogen.



A series of experiments was carried out in a reaction vessel at constant temperature. The initial rate of reaction increased by a factor of 2 when the initial pressure of NO was doubled and that of H₂ was halved.

When both pressures were halved, the initial rate decreased by a factor of 8.

Correct statements include

- 1 the overall order of reaction is 2.
 - 2 the reaction is first order with respect to hydrogen.
 - 3 the reaction is first order with respect to nitrogen monoxide.
 - 4 the overall order of reaction is 3.
- 25 Molecules or ions that contain an element with an oxidation state of +5 include
- 1 H₂SO₃
 - 2 NO₂⁺
 - 3 [Cr(H₂O)₄Cl₂]⁺
 - 4 ClO₃⁻

| Directions summarised | | | |
|-------------------------|----------------------|----------------------|----------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

26 The e.m.f. of the cell $\text{Zn(s)}|\text{Zn}^{2+}(\text{aq})||\text{Cu}^{2+}(\text{aq})|\text{Cu(s)}$, is +1.10 V

When the cell is in operation, correct statements include

- 1 oxidation occurs at the copper electrode.
- 2 electrons pass from copper to zinc.
- 3 the concentration of Zn^{2+} ions decreases.
- 4 the e.m.f. of the cell decreases.

27 Correct statements include

- 1 in the production of titanium, titanium(IV) oxide is reduced by carbon at a high temperature.
- 2 in the reduction of iron(III) oxide using carbon, there is a greater positive entropy change than in the reduction using carbon monoxide.
- 3 the melting point of barium is higher than that of calcium.
- 4 silicon(IV) chloride reacts with water to form a strongly acidic solution.

28 Lewis bases include

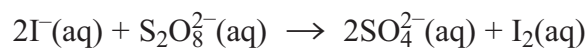
- 1 H_2O
- 2 NH_4^+
- 3 Cl^-
- 4 C_2H_6

| Directions summarised | | | |
|-------------------------|----------------------|----------------------|----------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

29 Correct statements about sulphuric acid include

- 1 concentrated sulphuric acid can be reduced to hydrogen sulphide by iodide ions.
- 2 1.713 g of barium hydroxide is neutralised exactly by 100 cm³ of 0.100 mol dm⁻³ sulphuric acid.
- 3 in sulphuric acid, the oxidation state of sulphur is +6.
- 4 the pH of 0.0200 mol dm⁻³ sulphuric acid is 1.70.

30 Consider the following reaction,



Ions which could catalyse this reaction include

- 1 Fe²⁺(aq)
- 2 Zn²⁺(aq)
- 3 Fe³⁺(aq)
- 4 Al³⁺(aq)

31 Correct statements about silver and its compounds include

- 1 silver bromide is insoluble in concentrated aqueous ammonia.
- 2 a silver-based catalyst is used in the oxidation of ethene to epoxyethane.
- 3 [Ag(NH₃)₂]⁺(aq) is reduced to silver by propanone.
- 4 silver bromide dissolves in aqueous sodium thiosulphate to form a linear complex ion.

| Directions summarised | | | |
|----------------------------|-------------------------|-------------------------|-------------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

32 The hydrolysis of a metal-aqua ion can be described by the general equation



In this reaction

- 1 the solvent H_2O is acting as a base by accepting a proton.
- 2 the pH of the solution will be lower if the value of n is 2 rather than 3.
- 3 the equilibrium position lies more to the right if the value of n is 3 rather than 2.
- 4 the oxidation state of the central metal cation has decreased from n to $n-1$.

33 Aqueous reagents that leave a precipitate after an excess has been added to separate samples of aqueous copper(II) sulphate include

- 1 NH_3
- 2 Na_2CO_3
- 3 HCl
- 4 NaOH

34 Reactions which involve a free-radical intermediate include

- 1 the nitration of benzene.
- 2 the acylation of methylamine with ethanoyl chloride.
- 3 the reduction of butanal with NaBH_4
- 4 the thermal cracking of octane.

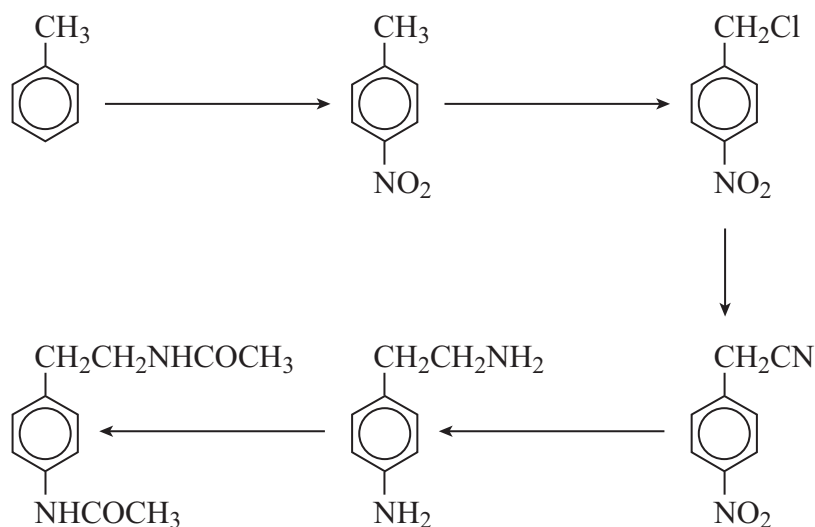
| Directions summarised | | | |
|----------------------------|-------------------------|-------------------------|-------------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

- 35 Correct statements about ammonia, methylamine and phenylamine include
- 1 the order of base strength is phenylamine < methylamine < ammonia.
 - 2 they all form amides with ethanoyl chloride.
 - 3 they all form acidic buffers with a suitable amount of hydrochloric acid.
 - 4 they all can act as nucleophiles and ligands using the lone pair on the nitrogen atom.
- 36 Compound X, $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}_2\text{OH}$, is found in freshly cut grass.
- Correct statements about X include
- 1 it has the systematic name hex-4-en-1-ol.
 - 2 it has the empirical formula $\text{C}_3\text{H}_6\text{O}$
 - 3 it has optical isomers.
 - 4 it has geometrical isomers.

Turn over for the next question

| Directions summarised | | | |
|-------------------------|----------------------|----------------------|----------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

37 Refer to the following reaction scheme.



Types of reaction involved in this scheme include

- 1 chlorination.
- 2 oxidation.
- 3 acylation.
- 4 alkylation.

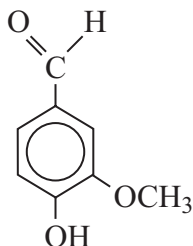
38 Amine **X**, $\text{H}_2\text{N}(\text{CH}_2)_5\text{NH}_2$, and acid **Y**, $\text{HOOC}(\text{CH}_2)_3\text{COOH}$, react to form polymer **Z**.

Correct statements include

- 1 polymer **Z** has a repeating unit with empirical formula $\text{C}_5\text{H}_9\text{NO}$
- 2 acid **Y** has the systematic name dibutanoic acid.
- 3 amine **X** has the systematic name pentane-1,5-diamine.
- 4 polymer **Z** is an addition polymer.

| Directions summarised | | | |
|----------------------------|-------------------------|-------------------------|-------------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

39 Vanillin (artificial vanilla flavouring) has the following structure.



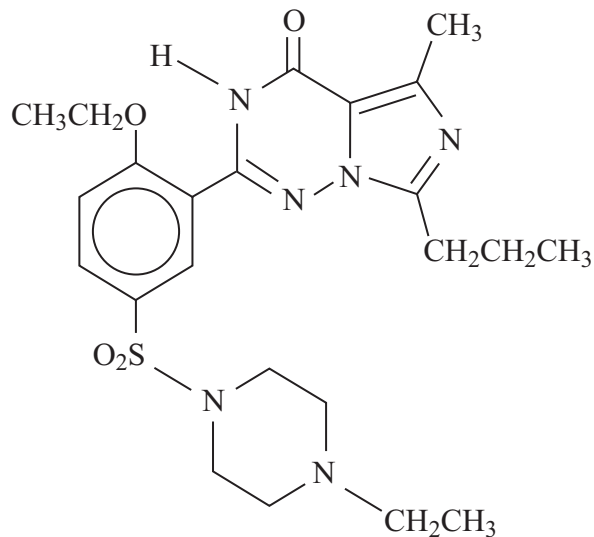
Correct statements about vanillin include

- 1 it contains an ester functional group.
- 2 it will produce a silver precipitate with Tollens' reagent.
- 3 it will undergo nucleophilic substitution.
- 4 it is able to undergo hydrogen bonding.

Turn over for the next question

| Directions summarised | | | |
|-------------------------|----------------------|----------------------|----------------|
| A | B | C | D |
| 1, 2 and 3 only correct | 1 and 3 only correct | 2 and 4 only correct | 4 only correct |

40 Levitra, an alternative to Viagra, has the following structure.



Correct statements about Levitra include

- 1 it reacts with dilute hydrochloric acid.
- 2 it exhibits geometrical isomerism.
- 3 it can be nitrated.
- 4 it can undergo condensation polymerisation.

END OF QUESTIONS