| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | Candidate Number | |
| Candidate Signature | | | |

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General Certificate of Education
June 2007
Advanced Level Examination

**CHEMISTRY** **CHM6/W**
**Unit 6a Synoptic Assessment**

Monday 25 June 2007 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 blue or 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.
- This paper carries 10 per cent of the total marks for Advanced Level.

## 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.

**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.

**Questions 1 and 2**

$$P(g) \rightleftharpoons 2Q(g) \qquad \Delta H^{\ominus} \text{ is positive}$$

**1** The mole fraction of Q in the above equilibrium can be increased by

**A** decreasing the temperature.

**B** adding a catalyst.

**C** increasing the volume of the reaction vessel.

**D** increasing the pressure.

**2** 1.0 mol of P was placed in a sealed vessel and left until the above equilibrium was established. At equilibrium, a total of 1.5 mol of gas were present. The mole fraction of Q at equilibrium was

**A** 0.33

**B** 0.50

**C** 0.67

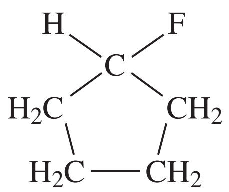
**D** 0.75

**3** The following compounds all have $M_r$ = 88. Which one contains over 60% by mass of carbon **and** also exhibits hydrogen bonding?

**A** $H_2N(CH_2)_4NH_2$

**B** $CH_3CH_2CH_2COOH$

**C** $CH_3CH_2CH_2CH_2CH_2OH$

**D** 

# 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.

**Key**

relative atomic mass — 6.9 **Li** Lithium — atomic number 3

| I | II | | | | | | | | | | | III | IV | V | VI | VII | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 **H** Hydrogen 1 | | | | | | | | | | | | | | | | | 4.0 **He** Helium 2 |
| 6.9 **Li** Lithium 3 | 9.0 **Be** Beryllium 4 | | | | | | | | | | | 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 | | | | | | | | | | | 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 | 45.0 **Sc** Scandium 21 | 47.9 **Ti** Titanium 22 | 50.9 **V** Vanadium 23 | 52.0 **Cr** Chromium 24 | 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 | 88.9 **Y** Yttrium 39 | 91.2 **Zr** Zirconium 40 | 92.9 **Nb** Niobium 41 | 95.9 **Mo** Molybdenum 42 | 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 | 138.9 **La** Lanthanum 57 * | 178.5 **Hf** Hafnium 72 | 180.9 **Ta** Tantalum 73 | 183.9 **W** Tungsten 74 | 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 | 227 **Ac** Actinium 89 † | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * **58 – 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 | 158.9 **Tb** Terbium 65 | 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 |
| † **90 – 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 $R = 8.31\ \mathrm{J\ K^{-1}\ mol^{-1}}$

**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 |

**4** $CaCl_2(s)$ has a standard lattice dissociation enthalpy of +2237 kJ $mol^{-1}$

The standard enthalpy of hydration values for $Ca^{2+}(g)$ and $Cl^{-}(g)$ are –1650 kJ $mol^{-1}$ and –364 kJ $mol^{-1}$, respectively.

The standard enthalpy of solution of $CaCl_2(s)$ is

**A** –223 kJ $mol^{-1}$

**B** –141 kJ $mol^{-1}$

**C** +141 kJ $mol^{-1}$

**D** +223 kJ $mol^{-1}$

**5** Ions of two isotopes of the transition metal nickel are shown below.

$^{58}_{28}Ni^{2+}$ $^{60}_{28}Ni^{2+}$

Which one of the following statements is correct?

**A** The electron arrangement of both these $Ni^{2+}$ ions is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$.

**B** The $^{60}_{28}Ni^{2+}$ ion will have more protons in its nucleus than the $^{58}_{28}Ni^{2+}$ ion.

**C** In the same strength magnetic field, the $^{60}_{28}Ni^{2+}$ ion will be deflected more than the $^{58}_{28}Ni^{2+}$ ion.

**D** These $Ni^{2+}$ ions have the same number of electrons but a different number of neutrons.

**Questions 6 and 7**

In questions **6** and **7** consider the data below.

| | $E^\ominus$/V |
|---|---|
| $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$ | +0.34 |
| $Ni^{2+}(aq) + 2e^- \longrightarrow Ni(s)$ | −0.25 |
| $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$ | −0.76 |

**6** The e.m.f. of the cell $Cu(s)|Cu^{2+}(aq)\|Ni^{2+}(aq)|Ni(s)$ is

**A** 0.59 V

**B** 0.09 V

**C** −0.09 V

**D** −0.59 V

**7** Which one of the following reactions occurs?

**A** $Cu(s) + 2H^+(aq) \longrightarrow Cu^{2+}(aq) + H_2(g)$

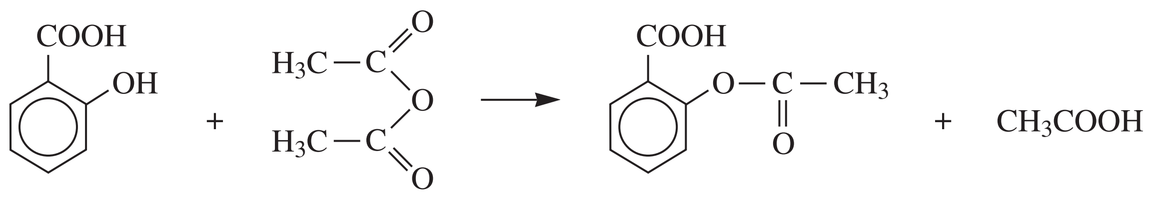
**B** $H_2(g) + Ni^{2+}(aq) \longrightarrow Ni(s) + 2H^+(aq)$

**C** $Cu(s) + Ni^{2+}(aq) \longrightarrow Cu^{2+}(aq) + Ni(s)$

**D** $Zn(s) + Ni^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Ni(s)$

**Questions 8 and 9**

The following reaction is used in industry to prepare aspirin




**8** Which one of the following statements about ethanoic anhydride is **not** correct?

**A** It has two singlets only in its proton n.m.r. spectrum.

**B** It undergoes hydrolysis in water to give a single product with a pH value less than 7.

**C** It has a strong absorption at about 1720 $cm^{-1}$ in its infra-red spectrum.

**D** It has a major fragment peak at $m/z$ = 43 in its mass spectrum.

**9** 2-Hydroxybenzoic acid and aspirin are both white solids.
Which one of the following would **not** distinguish between pure samples of these two solids?

**A** comparing the laboratory-determined melting points to data-book values

**B** comparing infra-red spectra at 3250 $cm^{-1}$

**C** comparing their effects on sodium carbonate

**D** comparing the $m/z$ values of their molecular ions

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**10** Which one of the following statements is correct?

**A** There are only three isomers of dichloropropane.

**B** There are geometric isomers of 2-methylpent-2-ene.

**C** There are optical isomers of 2-aminopropanoic acid.

**D** Enantiomers can be distinguished using the fingerprint region of their infra-red spectra.

**11** Aluminium chloride acts as a weak monoprotic acid in aqueous solution and has a $K_a$ value of $1.26 \times 10^{-5}$ mol dm$^{-3}$

What concentration, in mol dm$^{-3}$, of aluminium chloride will produce a solution with a pH value of 2.60?

**A** 0.0050

**B** 0.50

**C** 0.53

**D** 2.0

**12** Which one of the following statements is correct?

**A** $AlCl_3$ has a higher melting point than $Al_2O_3$

**B** The $Al_2Cl_6$ dimer contains two co-ordinate bonds.

**C** $AlCl_3$ is pyramidal.

**D** The $AlCl_3$ catalyst acts as an electron pair donor in the acylation of benzene.

**13** Which one of the following isomeric alkenes is formed when 3-bromo-2-methylpentane reacts with ethanolic potassium hydroxide?

**A** 3-methylpent-1-ene

**B** 3-methylpent-2-ene

**C** 4-methylpent-2-ene

**D** 2-ethylbut-1-ene

**14** Sulphur dichloride oxide, $SOCl_2$, can be used to convert alcohols into chloroalkanes.

$$CH_3CH_2OH + O{=}S\begin{smallmatrix}\diagup Cl\\ \diagdown Cl\end{smallmatrix} \longrightarrow CH_3CH_2Cl + O{=}S{=}O + HCl$$

| **Bond** | **Mean bond enthalpy / kJ mol$^{-1}$** |
|---|---|
| C–Cl | 338 |
| C–O | 364 |
| H–Cl | 431 |
| O–H | 464 |
| S–Cl | 277 |
| S=O | 523 |
| C–C | 348 |
| C–H | 412 |

The enthalpy change, in kJ mol$^{-1}$, for the gas phase reaction between ethanol and sulphur dichloride oxide using the bond enthalpies given above is

**A** –187

**B** –90

**C** +90

**D** +187

**Turn over for the next question**

**Questions 15 to 17**

A car airbag contains sodium azide, $NaN_3$, and potassium nitrate.
Sodium azide decomposes to produce nitrogen gas and sodium metal.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The sodium produced reacts immediately with the potassium nitrate producing more nitrogen.

$$10Na(s) + 2KNO_3(s) \longrightarrow N_2(g) + 5Na_2O(s) + K_2O(s)$$

**15** The total number of moles of nitrogen produced by 1.0 mol of sodium azide in this sequence is

**A** 1.0

**B** 1.5

**C** 1.6

**D** 4.0

**16** The number of moles of nitrogen needed to produce a pressure of 200 kPa in an airbag of volume 0.060 $m^3$ at a temperature of 27 °C is

**A** 0.21

**B** 4.8

**C** 54

**D** 4800

**17** An element which undergoes oxidation in the above reactions is

**A** sodium in $NaN_3$

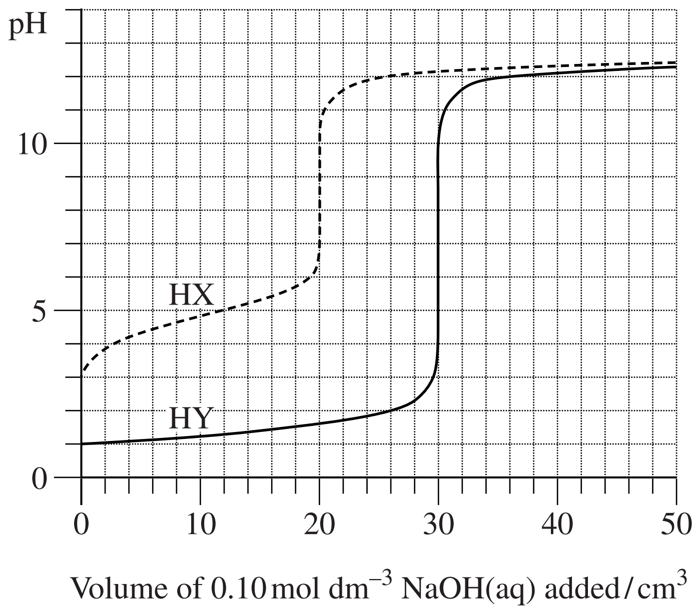
**B** potassium in $KNO_3$

**C** oxygen in $KNO_3$

**D** nitrogen in $NaN_3$

**Questions 18 and 19**

Use the curves below, obtained using equal volumes of solutions of two monoprotic acids **HX** and **HY**, to answer Questions **18** and **19**.




**18** Which one of the following statements about a solution of HX is correct?

**A** It is less concentrated and contains a weaker acid than the solution of HY.

**B** It is more concentrated and contains a stronger acid than the solution of HY.

**C** It is more concentrated and contains a weaker acid than the solution of HY.

**D** It is less concentrated and contains a stronger acid than the solution of HY.

**19** The value, in mol dm$^{-3}$, of $K_a$ for the acid HX is

**A** $1.3 \times 10^{-2}$

**B** $1.0 \times 10^{-3}$

**C** $1.3 \times 10^{-5}$

**D** $8.3 \times 10^{-6}$

**20** Which one of the following statements about carbon monoxide is **not** correct?

**A** It has a positive enthalpy of combustion.

**B** It is formed during the incomplete combustion of alkanes.

**C** It is oxidised to carbon dioxide when heated strongly with iron(III) oxide.

**D** Compared with an oxygen molecule, it can form a stronger co-ordinate bond with iron(II) in haemoglobin.

**21** Locate the element tungsten (W) in the Periodic Table.

Which one of the following explains why tungsten is a poor catalyst?

**A** It exists only in one oxidation state.

**B** It has an incomplete d sub-level.

**C** It has no active sites on its surface.

**D** Reacting molecules are adsorbed strongly onto its surface.

**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 extraction of titanium from titanium(IV) oxide involves two reactions represented by the following equations

$$TiO_2 + 2C + 2Cl_2 \longrightarrow TiCl_4 + 2CO$$

$$TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$$

Correct statements about the extraction include

**1** 149.6 kg of chlorine are needed to make 200.0 kg of titanium(IV) chloride ($M_r$ = 189.9).

**2** both of the above equations represent redox reactions.

**3** titanium is expensive because the extraction involves a batch process.

**4** the second reaction is carried out in an atmosphere of nitrogen to prevent oxidation of the product.

**23** Anhydrous compounds of Period 3 elements that react with water to give solutions with a pH value less than 5 include

**1** ionic chlorides.

**2** covalent chlorides.

**3** ionic oxides.

**4** covalent oxides.

| 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** Correct statements about concentrated sulphuric acid include

**1** it reacts with butan-2-ol to form but-1-ene.

**2** it is reduced to hydrogen sulphide by solid sodium iodide.

**3** it can protonate concentrated nitric acid.

**4** it reacts with sodium chloride to form chlorine gas.

**Questions 25 to 27** are about the synthesis and reactions of compounds **M** and **N** shown below.

$$\underset{\mathbf{J}}{CH_3COOH} \xrightarrow{\text{Step (i)}} \underset{\mathbf{K}}{ClCH_2COOH} \xrightarrow{\text{Step (ii)}} \underset{\mathbf{L}}{NCCH_2COOH} \xrightarrow{\text{Step (iii)}} \underset{\mathbf{M}}{HOOCCH_2COOH}$$

$$\mathbf{L} \xrightarrow{\text{Step (iv)}} \underset{\mathbf{N}}{H_2NCH_2CH_2COOH}$$

**25** Correct statements about the reaction scheme include

**1** Step (i) could be achieved using chlorine in the presence of ultra-violet light.

**2** Step (ii) could be achieved using potassium cyanide.

**3** Step (iv) could be achieved using hydrogen in the presence of nickel.

**4** **K** could be converted directly into **N** using ammonia.

**26** Correct statements about **M** include

**1** it can form a condensation polymer with 1,6-diaminohexane.

**2** complete reaction of 0.0100 mol of **M** requires 10.0 $cm^3$ of 1.00 mol $dm^{-3}$ NaOH(aq)

**3** it can act as a bidentate ligand.

**4** its systematic name is ethanedioic acid.

| 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 |

**27** Correct statements about **N** include

**1** it exists as the ion $HOOCCH_2CH_2NH_3^+$ in a solution at pH 14.

**2** it reacts with methanol to form a tetraalkylammonium salt.

**3** it reacts with ethanoyl chloride to form an ester.

**4** it undergoes self-polymerisation.

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**28** Results which support the identification of an unknown compound as propyl methanoate include

**1** a strong absorption in its infra-red spectrum at $1740\,cm^{-1}$.

**2** a singlet peak integrating for three protons in its proton n.m.r. spectrum.

**3** the compound contains 54.54% of carbon by mass.

**4** it effervesces with sodium hydrogencarbonate.

**29** Consider the species in the following equation.

$[Ti(H_2O)_4Cl_2]^+(aq) + 2H_2O(l) \rightleftharpoons [Ti(H_2O)_6]^{3+}(aq) + 2Cl^-(aq)$

Correct statements include

**1** water acts as a Lewis base.

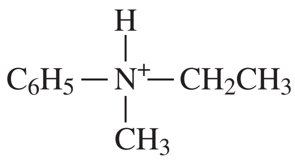
**2** the complex ions are both octahedral.

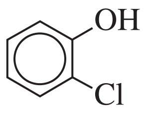
**3** the $[Ti(H_2O)_6]^{3+}$ ion can act as a Brønsted–Lowry acid.

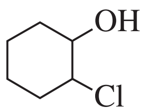
**4** the electron arrangement of the $Ti^{3+}$ ion is $[Ar]4s^1$

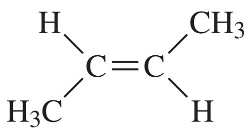
| Directions summarised | | | |
|---|---|---|---|
| **A** | **B** | **C** | **D** |
| **1**, **2** and **3** only correct | **1** and **3** only correct | **2** and **4** only correct | **4** only correct |

**30** Optical isomerism is shown by

**1** 

**2** 

**3** 

**4** 

**31** Species with four or more atoms in the same plane include

**1** cisplatin.

**2** but-2-ene.

**3** benzene.

**4** an ammonium 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** For the reaction represented by the equation shown below,

$$2H_2(g) + 2NO(g) \longrightarrow 2H_2O(g) + N_2(g)$$

the rate equation is

$$\text{rate} = k[H_2][NO]^2$$

Assuming that each 10 K rise in temperature doubles the rate, which of the following will increase the rate by a factor of four?

**1** a 20 K temperature increase, keeping $[H_2]$ and [NO] constant.

**2** a 10 K temperature increase with $2 \times [H_2]$, keeping [NO] constant.

**3** no temperature change but with $4 \times [H_2]$, keeping [NO] constant.

**4** a 10 K temperature increase with $2 \times$ [NO], keeping $[H_2]$ constant.

**33** Which of the following increase(s) down Group VII?

**1** the electronegativity of the halogen

**2** the lattice dissociation enthalpy of the sodium halide

**3** the oxidising ability of the halogen

**4** the strength of the halide ion as a reducing agent

**34** Correct statements include

**1** the base strength increases from methylamine to ammonia to phenylamine.

**2** the melting point increases from pentan-3-one to pentan-2-ol to 2-aminopropanoic acid.

**3** the carbon to carbon bond enthalpy increases from ethene to benzene to ethane.

**4** the pH of a 1.0 mol dm$^{-3}$ solution increases from sulphuric acid to hydrochloric acid to ethanoic acid.

| 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** Solids that have a macromolecular structure include

**1** $MgO$

**2** $C_{17}H_{35}COONa$

**3** $P_4O_{10}$

**4** $Si$

**36** Equations that represent redox reactions include

**1** $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

**2** $[V(H_2O)_4Cl_2]^+ + 2H_2O \longrightarrow [V(H_2O)_6]^{3+} + 2Cl^-$

**3** $Mg + S \longrightarrow MgS$

**4** $CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2$

| 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 |

**Questions 37 and 38**

Use the following reaction scheme to answer questions **37** and **38**.

$$\underset{\textbf{P}}{CH_3CH{=}CHCH_3} \longleftarrow \underset{\textbf{Q}}{CH_3CH(OH)CH_2CH_3} \longrightarrow \underset{\textbf{S}}{CH_3COCH_2CH_3}$$

$$\underset{\textbf{Q}}{CH_3CH(OH)CH_2CH_3} \longrightarrow \underset{\textbf{R}}{CH_3COOCH(CH_3)CH_2CH_3}$$

**37** Compounds that have stereoisomers include

**1** P

**2** Q

**3** R

**4** S

**38** Types of reaction in the scheme include

**1** dehydration.

**2** hydrogenation.

**3** esterification.

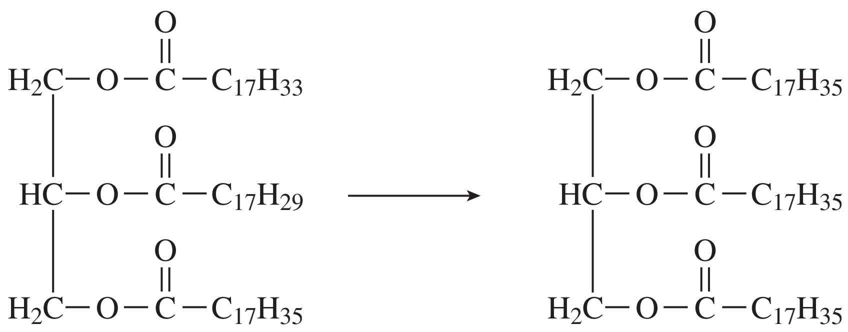
**4** alkylation.

| 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** Conversions that require four moles of hydrogen gas per mole of starting material include

**1** 

**2** $N{\equiv}C(CH_2)_4C{\equiv}N \longrightarrow H_2N(CH_2)_6NH_2$

**3** 

**4** 

**40** Correct statements about chloroethanoic acid include

**1** it gives an immediate white precipitate with silver nitrate solution.

**2** it gives a silver mirror with Tollens' reagent.

**3** it gives colourless fumes on addition of water.

**4** a mixture of acidified potassium dichromate(VI) and the acid remains orange on warming.

**END OF QUESTIONS**