Had a go ☐ Nearly there ☐ Nailed it! ☐

Exam skills 6

1 (a) Propanoic acid can be made from propan-1-ol by reaction with excess potassium dichromate(VI) solution, acidified with dilute sulfuric acid.

(i) Write an equation for the reaction.

..... **(1 mark)**

(ii) Draw a diagram to show the laboratory apparatus needed to make propanoic acid from propan-1-ol.

(3 marks)

(iii) Describe the colour change you would expect to see in the reaction.

..... **(1 mark)**

(iv) When the final reaction mixture is distilled, an aqueous solution of propanoic acid is produced. State why the excess reactants are left behind.

..... **(1 mark)**

(v) Suggest how you could produce pure propanoic acid from the solution of propanoic acid.

..... **(1 mark)**

(b) 1-iodopropane can be made by reacting propan-1-ol with phosphorus(III) iodide, PI_3.

(i) Write an equation to show the formation of phosphorus(III) iodide from moist red phosphorus and iodine.

..... **(1 mark)**

(ii) Write an equation to show the reaction between propan-1-ol and phosphorus(III) iodide.

..... **(1 mark)**

(iii) 1-iodopropane reacts with hot, aqueous silver nitrate solution. Describe what you would see when this reaction happens.

..... **(1 mark)**

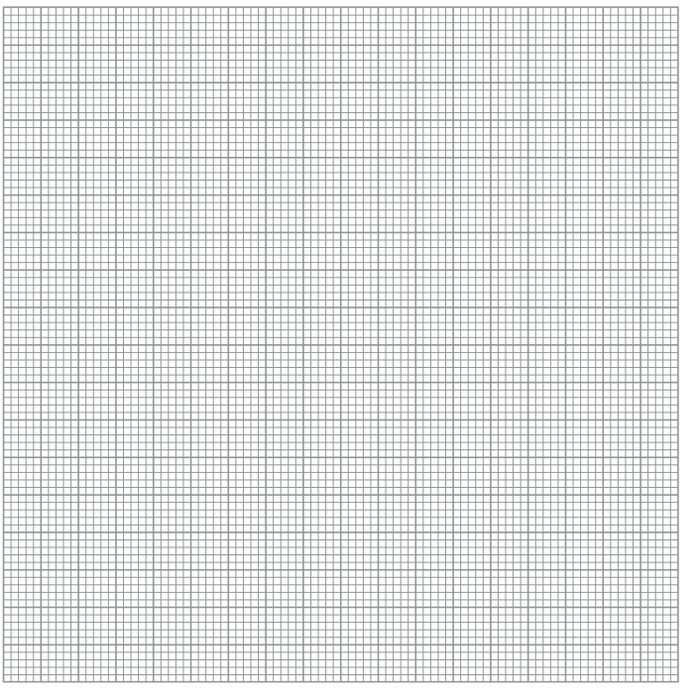
Exam skills 11

1 Nitrogen dioxide decomposes when heated:

$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$

The concentration of nitrogen dioxide was measured during a reaction.

(a) Use the table of data to plot a graph of $[NO_2]$ against t, and draw a line of best fit. **(4 marks)**



Time, t /s	$[NO_2]$ /mol dm^{-3}
0	1.00
50	0.79
100	0.65
150	0.55
200	0.48
250	0.43
300	0.38
350	0.34
400	0.31

(b) Explain, using information from your graph, why the order of reaction with respect to NO_2 could be first order or second order, but not zero order.

.....

.....

..... **(3 marks)**

(c) The instantaneous rate of reaction at different times can be determined from the graph plotted in part (a).

(i) Determine the instantaneous rate of reaction when $[NO_2] = 0.70$ mol dm^{-3}.

.....

..... **(3 marks)**

(ii) Explain how you would use the method used in part (i) to determine if the reaction is second order with respect to NO_2.

.....

.....

..... **(3 marks)**

Had a go ☐ Nearly there ☐ Nailed it! ☐

Methods in organic chemistry 2

1 Nitrobenzene, $C_6H_5NO_2$, can be reduced to form phenylamine, $C_6H_5NH_2$, using tin in concentrated hydrochloric acid. Which method can be used to separate phenylamine from the reaction mixture?

☐ **A** Recrystallisation

☐ **B** Filtration

☐ **C** Steam distillation

☐ **D** Chromatography **(1 mark)**

Practical skills

2 Ethanal can be produced by the oxidation of ethanol. Ethanol is mixed with acidified potassium dichromate(VI), and the mixture is heated under simple distillation conditions.

(a) Draw a labelled diagram to show the apparatus needed to carry out this synthesis.

(3 marks)

(b) If the reaction mixture is heated under reflux conditions instead, the product is ethanoic acid not ethanal. Draw a labelled diagram to show the apparatus needed to carry out this synthesis.

(3 marks)

3 Fragrant oils, such as lavender oil, are extracted from crushed plant material using steam distillation.

(a) Describe how steam distillation is carried out.

.....

..... **(3 marks)**

(b) Give an advantage of steam distillation over normal distillation.

..... **(1 mark)**

Had a go ☐ Nearly there ☐ Nailed it! ☐

pH of bases

1 (a) Write an equation for the dissociation of pure water.

..... **(1 mark)**

(b) Write an expression for the ionic product of water, K_w.

..... **(1 mark)**

(c) $K_w = 6.81 \times 10^{-15}\,mol^2\,dm^{-6}$ at 20 °C.
Calculate the pH of pure water at 20 °C, giving your answer to two decimal places.

In pure water, $[H^+(aq)] = [OH^-(aq)]$

.....

..... **(2 marks)**

(d) $K_w = 1.47 \times 10^{-14}\,mol^2\,dm^{-6}$ at 30 °C. Calculate the value for pK_w at 30 °C.

..... **(1 mark)**

2 Potassium hydroxide, KOH, is a strong base.

(a) State why potassium hydroxide is a strong base.

..... **(1 mark)**

Guided

(b) Calculate the pH of 0.0125 mol dm^{-3} KOH(aq) at 25 °C, giving your answer to three significant figures.
($K_w = 1.00 \times 10^{-15}\,mol^2\,dm^{-6}$ at 25 °C)

Rearrange the expression for K_w.

$[OH^-(aq)]$ = ...

$[H^+(aq)]$ = ...

pH = ... **(3 marks)**

3 The table shows values for standard enthalpy changes of neutralisation, $\Delta_{neut}H^{\ominus}$, for the reactions between sodium hydroxide solution and three acids.

Acid	$\Delta_{neut}H^{\ominus}$ /kJ mol^{-1}
HCl(aq)	−57.9
HNO_3(aq)	−57.6
HCN(aq)	−11.2

(a) State why the values of $\Delta_{neut}H^{\ominus}$ are very similar for hydrochloric acid and nitric acid.

..... **(1 mark)**

(b) Explain why the value of $\Delta_{neut}H^{\ominus}$ for hydrogen cyanide is so different from the other two values.

.....

..... **(2 marks)**

Had a go ☐ Nearly there ☐ Nailed it! ☐

Shapes of molecules and ions

1 For each molecule below, draw a diagram to show its shape and bond angle.

(a) CO_2

(2 marks)

(b) CH_4

(2 marks)

(c) $AlCl_3$

(2 marks)

(d) PF_5

(2 marks)

2 Which of the following has a shape that is **not** influenced by a lone pair of electrons?

☐ **A** BCl_3

☐ **B** PF_3

☐ **C** CH_3^-

☐ **D** H_2O

(1 mark)

CH_3^- has one more electron than CH_3 would have (and NH_4^+ has one less electron than NH_4 would have).

3 The three species NH_4^+, NH_3 and NH_2^- all contain nitrogen but have different shapes and bond angles. For each one, predict its shape and bond angle, and explain your answer.

(a) NH_4^+ shape and bond angle .....

Explanation .....

..... **(3 marks)**

(b) NH_3 shape and bond angle .....

Explanation .....

..... **(3 marks)**

(c) NH_2^- shape and bond angle .....

Explanation .....

..... **(3 marks)**

4 Which of the following is a correct statement about a molecule of SF_6?

☐ **A** It is trigonal bipyramidal with bond angles of 90° and 120°.

☐ **B** It is trigonal bipyramidal with bond angles of 90° and 180°.

☐ **C** It is octahedral with bond angles of 90° and 120°.

☐ **D** It is octahedral with all bond angles of 90°. **(1 mark)**

Shells, sub-shells and orbitals

Guided

1 Electrons in atoms occupy orbitals. Explain what is meant by the term **orbital**.

An orbital is a region .....

..... **(1 mark)**

2 (a) The electrons in an orbital can be shown as arrows. State the property represented by these arrows.

..... **(1 mark)**

(b) Draw diagrams in the spaces below to show the shapes of an s-orbital and a p-orbital.

s-orbital	**p-orbital**

(2 marks)

3 Complete the table to show the maximum number of electrons that can occupy s-, p- and d-sub-shells.

Sub-shell	s	p	d
Maximum number of electrons			

(1 mark)

4 Which of the following represents the correct maximum numbers of electrons allowed in each of the first four quantum shells?

	1st	2nd	3rd	4th
☐ **A**	2	8	8	18
☐ **B**	2	8	8	32
☐ **C**	2	8	18	32
☐ **D**	2	6	8	18

(1 mark)

5 Which of the following statements correctly describes 1s and 4s sub-shells?

☐ **A** 1s is closer to the nucleus and higher in energy than 4s.

☐ **B** 1s is closer to the nucleus and lower in energy than 4s.

☐ **C** 1s is further from the nucleus and higher in energy than 4s.

☐ **D** 1s is further from the nucleus and lower in energy than 4s. **(1 mark)**

Stability of carbonates and nitrates

1 Explain what is meant by the term **thermal decomposition**.

..... **(1 mark)**

Guided

2 Which of the following substances are produced when lithium nitrate is heated?

☐ **A** lithium nitrite, nitrogen dioxide and oxygen

☐ **B** lithium nitrite and oxygen

☐ **C** lithium oxide, nitrogen dioxide and oxygen

☐ **D** lithium oxide and oxygen. **(1 mark)**

Option **D** cannot be correct because it does not contain a nitrogen compound.

3 Potassium nitrate, KNO_3, and calcium nitrate, $Ca(NO_3)_2$, decompose when heated.

(a) Write an equation for the decomposition of potassium nitrate.

..... **(2 marks)**

(b) Write an equation for the decomposition of calcium nitrate.

..... **(2 marks)**

4 Potassium carbonate and magnesium carbonate are both white solids.
What happens when they are heated strongly?

☐ **A** Potassium carbonate decomposes but magnesium carbonate does not decompose.

☐ **B** Magnesium carbonate decomposes but potassium carbonate does not decompose.

☐ **C** Neither carbonate decomposes.

☐ **D** Both carbonates decompose. **(1 mark)**

5 Limestone is mainly calcium carbonate. Cement is made by heating a mixture of powdered limestone and clay in a kiln.

(a) Write an equation for the decomposition of calcium carbonate.

..... **(1 mark)**

(b) Strontium carbonate is used in the manufacture of electroluminescent materials, such as those used in alarm clock faces. It must be heated first to decompose it to strontium oxide.

(i) Which substance, $CaCO_3$ or $SrCO_3$, needs the higher temperature to decompose?

..... **(1 mark)**

(ii) Explain the difference in stability between these two carbonates.

Factors to consider include the size of the metal ion and how much it affects the anion.

.....

.....

..... **(3 marks)**

Vanadium chemistry

1 (a) Which row contains the correct colour of each ion in solution?

	V^{2+}	V^{3+}	VO_2^+	VO^{2+}
☐ **A**	yellow	blue	green	purple
☐ **B**	purple	green	blue	yellow
☐ **C**	purple	green	yellow	blue
☐ **D**	yellow	blue	purple	green

(1 mark)

(b) State the oxidation state of vanadium in each of the ions shown in part (a).

V^{2+} ..... V^{3+} .....

VO_2^+ ..... VO^{2+} ..... **(3 marks)**

You will need these standard electrode potential values to answer some of these questions.

Right-hand electrode system	$E^\ominus$/V
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	−0.76
$V^{3+} + e^- \rightleftharpoons V^{2+}$	−0.26
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00

The Data Booklet given to you in examinations contains a table of standard electrode potentials.

2 Ammonium trioxovanadate(V), NH_4VO_3, forms the dioxovanadium(V) ion, VO_2^+, in acidic conditions. This can be reduced using zinc with sulfuric acid or hydrochloric acid.

(a) (i) Write an equation to show the reduction of vanadium(III) ions to vanadium(II) ions using zinc.

..... **(1 mark)**

(ii) Explain, using electrode potentials, whether this reaction is feasible under standard conditions.

Calculate $E^\ominus_{right} - E^\ominus_{left}$ where the reduction half-equation refers to $E^\ominus_{right}$.

.....

..... **(2 marks)**

(b) (i) Write an equation to show the reduction of VO_2^+ ions to V^{2+} ions using zinc.

.....

.....

..... **(2 marks)**

(ii) State why this reaction is feasible under standard conditions.

..... **(1 mark)**