PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



EXAM QUESTION PACK

TOPIC 2: BONDING AND STRUCTURE

SCORE	PERCENTAGE
/196	%

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Q1.

This question is about acids and buffer solutions.

Ethanoic acid, CH_3COOH, is a monobasic acid.

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

Give a reason why only the proton from the carboxylic acid group, and not from the methyl group, is donated to a water molecule.

(1)

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(Total for question = 1 mark)

Q2.

This is a question about alkanes.

Alkanes are obtained by processing crude oil.

(i) Explain why different alkanes in crude oil can be separated by fractional distillation.

(2)

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(ii) Complete the equation for the cracking of octane to produce ethene and only one other organic compound. State symbols are not required.

(1)

C_8H_{18} → ..... + ...

(iii) Write the equation for the reforming of hexane into cyclohexane, using **displayed** formulae for the organic compounds. State symbols are not required.

(1)

(Total for question = 4 marks)

Q3.

An experiment to determine the equilibrium constant for the reaction between sodium fluoride solution and magnesium hydroxide is carried out.

100 cm^3 of sodium fluoride solution, of concentration 0.250 mol dm^{-3}, is added to a conical flask. Excess solid magnesium hydroxide is added and the mixture is left for 24 hours to reach equilibrium.

The mixture is filtered and 25.0 cm^3 of the solution is removed and titrated with hydrochloric acid.

11.70 cm^3 of 0.100 mol dm^{-3} HCl(aq) is required to neutralise the NaOH formed.

(a) Draw a dot-and-cross diagram of the ions in $Mg(OH)_2$.
Show outer electrons only.

(2)

(b) (i) Use the data to calculate the equilibrium constant, K_c for the reaction between NaF and $Mg(OH)_2$.
Give your answer to an appropriate number of significant figures and give the units, if any.

$$2NaF(aq) + Mg(OH)_2(s) \rightleftharpoons 2NaOH(aq) + MgF_2(s)$$

(5)

(b) (ii) The experiment was repeated on different days.
Justify whether this would improve the reliability of the data collected.

(1)

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(Total for question = 8 marks)

Q4.

This is a question about water.

Water might be expected to have a lower boiling temperature than hydrogen sulfide but it actually has a higher boiling temperature.

Comment on this statement by referring to the intermolecular forces in both these substances.

A detailed description of how the intermolecular forces arise is not required.

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(Total for question = 4 marks)

Q5.

This question is about compounds of Group 5 elements.

Nitrogen trichloride, NCl_3, has a boiling temperature of 344 K, and nitrogen trifluoride, NF_3, has a boiling temperature of 144 K.

Explain this difference in boiling temperatures, by referring to all the intermolecular forces present.

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(Total for question = 5 marks)

Q6.

This question is about halogens and redox reactions.

The boiling temperatures of three halogens are shown in the table.

Halogen	Boiling temperature / °C
chlorine	–35
bromine	59
iodine	184

Explain why the boiling temperatures increase from chlorine to iodine.

(2)

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(Total for question = 2 marks)

Q7.

This question is about methanol, CH_3OH .

Draw a dot-and-cross diagram to show the bonding in a molecule of methanol.
Show outer shell electrons only.

(2)

(Total for question = 2 marks)

Q8.

This question is about methanol, CH_3OH .

Predict which bond has the shortest bond length in a molecule of methanol.

(1)

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(Total for question = 1 mark)

Q9.

This question is about the bonding and structure of molecules.

(a) Which element exists as discrete molecules in its solid state?

(1)

☒ **A** aluminium

☒ **B** iodine

☒ **C** silicon

☒ **D** sodium

(b) Which compound has non-polar molecules?

(1)

☒ **A** ammonia

☒ **B** carbon dioxide

☒ **C** hydrogen sulfide

☒ **D** water

(c) Which is the best reason for why the boiling temperature of HF is much higher than that of HCl?

(1)

☒ **A** the instantaneous dipole-induced dipole (London) forces are stronger in HF

☒ **B** HF molecules have a smaller mass

☒ **C** there are intermolecular hydrogen bonds in HF

☒ **D** HF molecules have fewer electrons

Q10.

This question is about transition metals and transition metal complexes.

Describe the bonding in the element chromium and use your answer to justify why it has such a high melting temperature.

You may find it helpful to draw a labelled diagram.

(4)

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(Total for question = 4 marks)

Q11.

This question is about the chemistry of hydrated magnesium nitrate, $Mg(NO_3)_2.xH_2O$.

In an experiment, a sample of hydrated magnesium nitrate, $Mg(NO_3)_2.xH_2O$, with a mass of 0.765 g, was dissolved in water and reacted with an excess of sodium hydroxide solution, NaOH(aq).
The precipitate of magnesium hydroxide, $Mg(OH)_2$, produced was removed and dried. The mass of the dried sample was 0.174 g.

(i) Draw dot-and-cross diagrams for the ions in magnesium hydroxide.
Show the outer electrons only.

(2)

(ii) Use the experimental data to calculate the value for x in the formula $Mg(NO_3)_2.xH_2O$.
You **must** show all your working.

(5)

(Total for question = 7 marks)

Q12.

Prussian Blue, $[Fe_4[Fe(CN)_6]_3]$, is a dark blue pigment used in painting and dyeing.

It was discovered around 1700 AD in the German state of Prussia.

Prussian Blue is formed when an iron(III) salt is added to a solution containing the complex ion $[Fe(CN)_6]^{4-}$.

The cyanide ion has the formula CN^-.

(a) (i) The oxidation number of Fe in the $[Fe(CN)_6]^{4-}$ ion is

(1)

☒ **A** +2

☒ **B** +3

☒ **C** +4

☒ **D** +6

(ii) Draw a diagram to show the shape of a $[Fe(CN)_6]^{4-}$ ion, using the structure CN^- to represent a cyanide ligand and showing how the cyanide ligands bond to the central iron ion.

(2)

(b) A solution containing $[Fe(CN)_6]^{3-}$ ions can be made from $[Fe(H_2O)_6]^{2+}$ ions in two steps as shown:

Step 1 $[Fe(H_2O)_6]^{2+}(aq) + 6CN^-(aq) \rightleftharpoons [Fe(CN)_6]^{4-}(aq) + 6H_2O(l)$

Step 2 $2[Fe(CN)_6]^{4-}(aq) + Cl_2(aq) \rightarrow 2[Fe(CN)_6]^{3-}(aq) + 2Cl^-(aq)$

Name the type of reaction taking place in each of Steps 1 and 2.

(2)

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(c) In a separate reaction, aqueous sodium hydroxide was added to a solution containing iron(II) sulfate. A green precipitate formed that turned brown on standing in air.

Identify the green precipitate and explain why it turns brown on standing in air.

(3)

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Q13.

This question is about compounds of Group 5 elements.

Phosphorus forms two chlorides with the formulae PCl_3 and PCl_5.

(i) Explain the shape of the PCl_3 molecule. The bond angle is not required.

(3)

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(ii) Draw a diagram to show the three-dimensional shape of the PCl_5 molecule in the gas phase.

Include bond angles and the name of the shape.

(3)

(iii) Explain why phosphorus forms PCl_5 but nitrogen does not form NCl_5.

(2)

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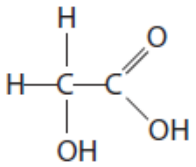
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(Total for question = 8 marks)

Q14.

2-Hydroxyethanoic acid, also known as glycolic acid, $CH_2OHCOOH$, is an alpha hydroxy acid used in some skincare products.
It has a K_a value of 1.5×10^{-4} mol dm^{-3}.

The structure of glycolic acid is



Glycolic acid has an acid dissociation constant of 1.5×10^{-4} mol dm^{-3} compared with a value of 1.7×10^{-5} mol dm^{-3} for ethanoic acid.

(i) Give a possible explanation as to why the value of K_a for glycolic acid is approximately ten times larger than that of ethanoic acid.

(2)

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(ii) Complete the equation to show the conjugate acid-base pairs that would be produced when pure samples of glycolic acid and ethanoic acid are mixed.

(1)

$CH_2OHCOOH + CH_3COOH \rightarrow$ ..... +
.....

(Total for question = 3 marks)

Q15.

This question is about aluminium chloride.

Aluminium chloride exists as a dimer, Al_2Cl_6, just above its boiling temperature.

(i) Draw a diagram to show how two $AlCl_3$ molecules are joined together in the dimer.

(1)

(ii) State the type of bond that joins the two $AlCl_3$ molecules together.

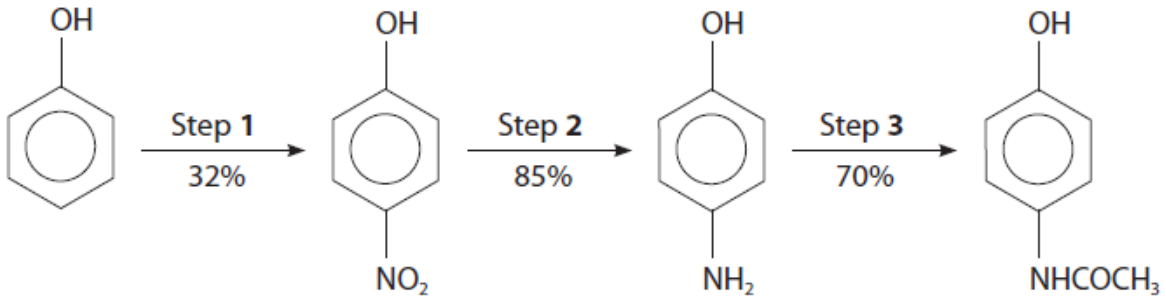
(1)

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(Total for question = 2 marks)

Q16.

The painkiller paracetamol can be synthesised from phenol in three steps.
The percentage yield for each step is shown.



phenol paracetamol

Explain why amino acids such as glycine are crystalline solids at room temperature.

(2)

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(Total for question = 2 marks)

Q17.

This question is about the chemistry of the alcohol functional group.

Ethanol and water mix together readily because of the formation of hydrogen bonds between the molecules.

Devise an experiment to estimate the strength of this interaction including how you would process the data collected.

(6)

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Q18.

Diamond, graphene and graphite are different forms of carbon.

One way in which diamond differs from graphene and graphite is that only diamond has

(1)

- ☒ **A** a high melting temperature
- ☒ **B** a precise molecular formula
- ☒ **C** poor electrical conductivity
- ☒ **D** a giant structure

(Total for question = 1 mark)

Q19.

This question is about carbon monoxide, CO, which is a toxic and colourless gas used widely in the chemical industry.

Draw a dot-and-cross diagram of a molecule of carbon monoxide.

Use dots (•) for the carbon electrons and crosses (×) for the oxygen electrons.

(2)

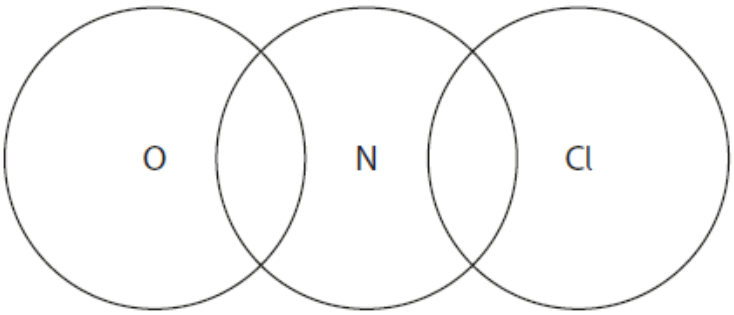
(Total for question = 2 marks)

Q20.

Nitrogen monoxide and chlorine react together to form nitrosyl chloride.

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$$

Draw a dot-and-cross diagram for nitrosyl chloride, showing only the outer shell electrons.



(Total for question = 2 marks)

Q21.

Draw a dot-and-cross diagram to show the bonding in a molecule of propene.

Only outer shell electrons should be shown.

(2)

Q22.

Magnesium bromide, $MgBr_2$, is an ionic compound.

(i) Draw a dot-and-cross diagram to show the bonding in magnesium bromide.

Only outer shell electrons are required.

(1)

(ii) State all the conditions under which magnesium bromide conducts electricity.

(1)

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(Total for question = 2 marks)

Q23.

This question is about aluminium chloride.

At high temperatures, aluminium chloride exists as $AlCl_3$ molecules.

(i) Draw a dot-and-cross diagram of an aluminium chloride molecule, $AlCl_3$. Show the outer shell electrons only.

(1)

(ii) Predict the shape of an $AlCl_3$ molecule and the Cl−Al−Cl bond angle.

(2)

Shape of $AlCl_3$	
Cl–Al–Cl bond angle	

(iii) Aluminium chloride is used as a catalyst in the alkylation of benzene.

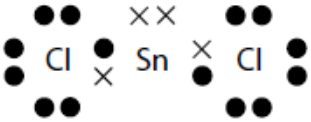
Draw the mechanism for the reaction between benzene and chloromethane using aluminium chloride as the catalyst.
Include an equation for the formation of the electrophile, and any relevant curly arrows.

(4)

(Total for question = 7 marks)

Q24.

The dot-and-cross diagram for a molecule of tin(II) chloride, SnCl2, in the gaseous state is:



(i) Using the electron-pair repulsion theory, explain the shape of this molecule.

(2)

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(ii) Predict a value for the Cl–Sn–Cl bond angle.

Justify your answer.

(2)

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Q25.

Using a dot-and-cross diagram, explain why the superoxide ion, O––O^-, is a radical.

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Q26.

Tablets containing potassium manganate(VII), $KMnO_4$, are dissolved in water forming an

antiseptic solution to treat skin conditions. The manufacturers claim that each tablet contains 400 mg of $KMnO_4$.

To check the claim, the titration procedure outlined was carried out.

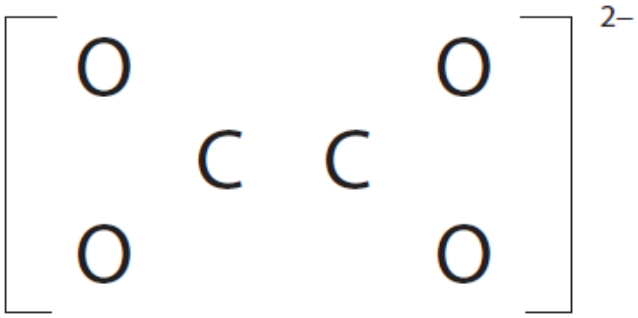
- Five tablets were dissolved in distilled water to make 100.0 cm^3 of solution.
- Some of the $KMnO_4$ solution was used to fill a burette.
- 25.0 cm^3 of sodium ethanedioate solution, $Na_2C_2O_4(aq)$, of concentration 0.200 mol dm^{-3}, was added to a conical flask and warmed.
- Sulfuric acid, of concentration 2 mol dm^{-3}, was also added to the conical flask.
- The $KMnO_4$ solution was added to the flask from the burette, until the end-point.

The equation for the reaction between MnO_4^- ions from the $KMnO_4$ and $C_2O_4^{2-}$ ions from the sodium ethanedioate solution is shown.

$$16H^+(aq) + 2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$$

(i) Complete the dot-and-cross diagram for the ethanedioate ion.
Show the outer electrons only.

(2)



(ii) Determine the oxidation number of carbon in the ethanedioate ion, $C_2O_4^{2-}$.

(1)

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(Total for question = 3 marks)

Q27.

Traditionally, high-flying aircraft and Formula 1 racing cars have had their tyres inflated with nitrogen gas instead of air. Recently, this practice has been extended to some other cars.

One reason for the use of nitrogen gas in car tyres is that less gas is lost from the tyres during use because nitrogen molecules are larger than oxygen molecules.

A suggested explanation for this is that nitrogen atoms are larger than oxygen atoms.

Explain why a nitrogen atom is larger than an oxygen atom.

(2)

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(Total for question = 2 marks)

Q28.

This is a question about halogenoalkanes and related compounds.

Explain why ethene has a boiling temperature of −104 °C, whereas ethanol has a boiling temperature of 78 °C.

(3)

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(Total for question = 3 marks)

Q29.

Benzene (T_b = 80.1°C) has a higher boiling temperature than ethanol (T_b = 78.5°C).
This is because the

☒ **A** benzene ring is stabilised.

☒ **B** London forces between benzene molecules are stronger than the hydrogen bonds between ethanol molecules.

☒ **C** hydrogen bonds between benzene molecules are stronger than the hydrogen bonds between ethanol molecules.

☒ **D** C–H bonds in benzene are stronger than the C–H bonds in ethanol.

(Total for question = 1 mark)

Q30.

Diamond, graphene and graphite are different forms of carbon.

The structural feature that graphene and graphite have in common is that the carbon atoms are arranged in

(1)

☒ **A** layers with each atom bonded to four others

☒ **B** hexagonal and pentagonal rings within a layer

☒ **C** hexagonal rings within a layer

☒ **D** a three-dimensional structure

(Total for question = 1 mark)

Q31.

Give the formula of a stable **ion** that is isoelectronic with the magnesium ion, Mg^{2+}.

(1)

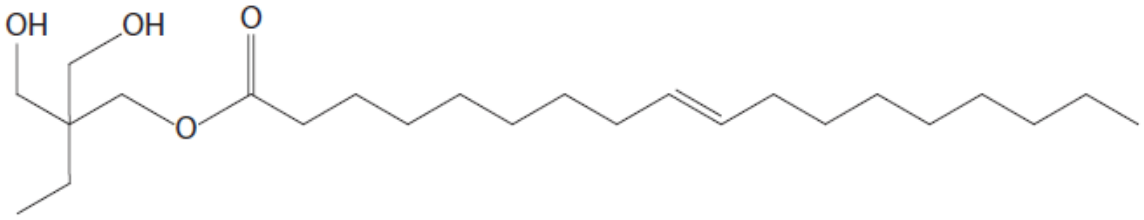
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(Total for question = 1 mark)

Q32.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Compound **X** is a component of synthetic oils used as lubricants, for instance in the gearboxes of ships.



compound **X**

An alternative to synthetic oil is known as mineral oil and consists solely of hydrocarbons separated from crude oil.

(i) What is the name of the process used to separate different hydrocarbons from crude oil?

(1)

☒ **A** cracking

☒ **B** reforming

☒ **C** fractional distillation

☒ **D** heating under reflux

(ii) Explain why compound **X** is likely to have a higher boiling temperature than hydrocarbons of a similar molecular mass and shape.

A detailed description of how the intermolecular forces arise is not required.

(2)

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(Total for question = 3 marks)

Q33.

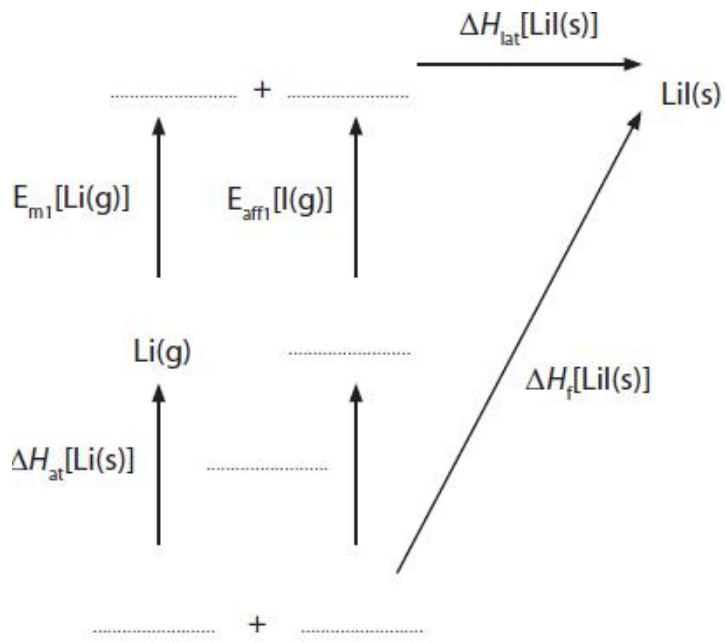
This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



(c) Calculate the electron affinity of iodine, E_{aff1}[I(g)], using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	–759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	–270

(2)

(d) The experimental lattice energy for lithium iodide is -759 kJ mol^{-1}. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

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(e) State and explain how electron affinity values change as you go down Group 7 from chlorine to iodine.

(2)

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(Total for question = 12 marks)

Q34.

Butylamine (T_b = 77.8°C) has a higher boiling temperature than propylamine (T_b = 47.7°C). This is because the

☒ **A** hydrogen bonds of butylamine are stronger than the hydrogen bonds of propylamine.

☒ **B** London forces of butylamine are stronger than the hydrogen bonds of propylamine.

☒ **C** London forces of butylamine are stronger than the London forces of propylamine.

☒ **D** C—H bonds of butylamine are stronger than the C—H bonds of propylamine.

(Total for question = 1 mark)

Q35.

This question is about the properties of amino acids and other organic compounds.

Some data about different organic compounds is shown in the table.

Compound	Relative molecular mass	Melting temperature / °C
glycine (an amino acid)	75	233
butan-1-ol	74	–90
pentane	72	–130

Use information from the table to justify the types of intermolecular forces in each of these compounds.

(4)

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Q36.

This is a question about water.

Pure water ionises to form H_3O^+ and OH^- ions, although only to a very small extent.
Draw the dot-and-cross diagrams of these ions.
Use dots (•) for the hydrogen electrons and crosses (×) for the oxygen electrons.

(2)

(Total for question = 2 marks)

Q37.

Boric acid, H_3BO_3, is a weak acid with antiseptic properties.

Boric acid is a solid with melting temperature 171 °C.

What are the strongest interactions between the molecules in solid boric acid?

(1)

☒ **A** covalent bonds

☒ **B** hydrogen bonds

☒ **C** ionic bonds

☒ **D** London forces

(Total for question = 1 mark)

Q38.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

This is a question about atoms, isotopes and ions.

Which of the following pairs of ions is isoelectronic?

(1)

☒ **A** N^{3-} and Cl^-

☒ **B** O^{2-} and S^{2-}

☒ **C** Na^+ and K^+

☒ **D** Na^+ and Mg^{2+}

(Total for question = 1 mark)

Q39.

This question is about some halogens and their compounds.

The intermolecular attractions between halogen molecules are London forces.

(i) Describe how London forces form between halogen molecules.

(3)

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(ii) The boiling temperatures of chlorine and bromine are shown in the table.

Halogen	Boiling temperature / °C
chlorine	−34
bromine	59

Explain why bromine has a higher boiling temperature than chlorine.

(2)

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(Total for question = 5 marks)

Q40.

This question is about catalytic converters.

Catalytic converters contain metals such as platinum.

Describe the bonding in platinum.
You may include a diagram in your answer.

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(Total for question = 2 marks)

Q41.

Boric acid, H_3BO_3, is a weak acid with antiseptic properties.

The formula of boric acid can also be written as $B(OH)_3$.

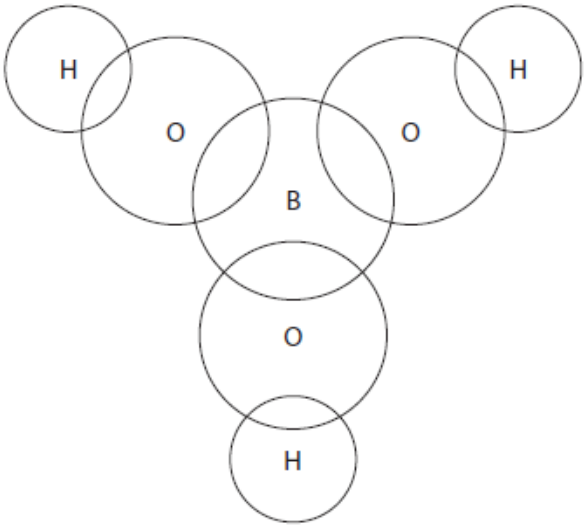
(i) Complete the dot-and-cross diagram of a molecule of boric acid. Show the outer shell electrons only.

(1)

Use dots (•) for the hydrogen electrons, crosses (×) for the oxygen electrons and triangles (△)

for the boron electrons.

(2)



(ii) What are the O—B—O and B—O—H bond angles in a molecule of boric acid?

	O—B—O bond angle	B—O—H bond angle
☒ **A**	109.5°	104.5°
☒ **B**	109.5°	180°
☒ **C**	120°	104.5°
☒ **D**	120°	180°

(Total for question = 3 marks)

Q42.

This question is about some hydrocarbons.

(i) Which isomeric alkane has the lowest boiling temperature?

(1)

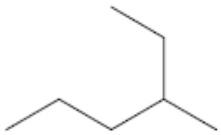
☒ **A** 2,2-dimethylbutane

☒ **B** hexane

☒ **C** 3-methylpentane

☒ **D** 2-methylpentane

(ii) What is the name of this alkane?



(1)

☒ **A** 4-ethylpentane

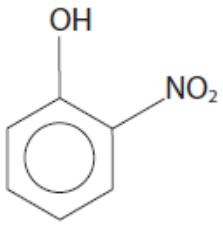
☒ **B** 2-ethylpentane

☒ **C** 4-methylhexane

☒ **D** 3-methylhexane

Q43.

Phenol reacts with dilute nitric acid at room temperature to form a mixture of 2-nitrophenol and 4-nitrophenol.



2-nitrophenol



4-nitrophenol

(i) Explain why phenol reacts with nitric acid more readily than benzene.

(2)

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(ii) Suggest an explanation for 2-nitrophenol being less soluble in water than 4-nitrophenol.

(2)

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Q44.

This is a question about water.

Explain why both water and carbon dioxide molecules have polar bonds but only water is a polar molecule.

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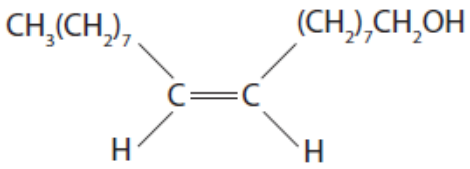
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(Total for question = 4 marks)

Q45.

The formula for oleyl alcohol, which is present in sperm whale oil and was used as a lubricant, is shown below.



(a) The systematic name for oleyl alcohol is

(1)

☒ **A** *E*-octadec-9-en-1-ol.

☒ **B** *Z*-octadec-9-en-1-ol.

☒ **C** *E*-octadec-8-en-1-ol.

☒ **D** *Z*-octadec-8-en-1-ol.

(b) Which intermolecular forces are present between oleyl alcohol molecules?

(1)

☒ **A** London forces only

☒ **B** Hydrogen bonds and London forces only

☒ **C** Hydrogen bonds and permanent dipole–dipole forces only

☒ **D** Hydrogen bonds, permanent dipole–dipole and London forces

(c) Which of the following is the most likely structure of the species to cause a peak at *m/e* 31 in the mass spectrum of oleyl alcohol?

(1)

☒ **A** CH_3O

☒ **B** CH_2OH

☒ **C** CH_3O^+

☒ **D** CH_2OH^+

(d) What would you expect to see if oleyl alcohol is tested separately with bromine water and heated with acidified sodium dichromate(VI) solution?

(1)

	Bromine water	Acidified sodium dichromate(VI) solution
☒ **A**	Decolorises	Turns green
☒ **B**	No colour change	No colour change
☒ **C**	Decolorises	No colour change
☒ **D**	No colour change	Turns green

(Total for question = 4 marks)

Q46.

Four organic compounds are:

A CH_3OH

B HCHO

C HCOOH

D $HCOOCH_3$

(a) Which of these compounds has a fruity smell?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) 0.01 mol of each compound is added separately to identical volumes of water.
Which solution would have the lowest pH?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) 0.01 mol of each compound is heated separately with excess acidified sodium

dichromate(VI) solution. Which compound reduces the largest amount of sodium dichromate(VI)?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which compound has the highest boiling temperature?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(e) Which of these compounds can be oxidized by ammoniacal silver nitrate?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 5 marks)

Q47.

Brass is an alloy of copper and zinc.

(i) Explain why copper is classified as a transition element but zinc is not.

(2)

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(ii) Brass has a structure similar to that of metallic copper, but with zinc ions replacing some copper ions in the lattice.

Explain why brass is malleable whereas a crystal of sodium chloride is not.

(3)

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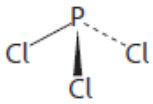
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Q48.

A phosphorus atom has mass number 31.

Phosphorus(III) chloride molecules are pyramidal with a bond angle less than 109.5°.



(i) Explain why a phosphorus(III) chloride molecule has this shape and bond angle.

(2)

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(ii) Which describes the polarity of the P—Cl bond and the polarity of the phosphorus(III) chloride molecule?

(1)

	Polarity of P—Cl bond	Polarity of molecule
☒ **A**	non-polar	non-polar
☒ **B**	non-polar	polar
☒ **C**	polar	non-polar
☒ **D**	polar	polar

(Total for question = 3 marks)

Q49.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about atoms, molecules and ions.

Which of these isoelectronic ions has the largest ionic radius?

(1)

☒ **A** N^{3-}

☒ **B** O^{2-}

☒ **C** Na^{+}

☒ **D** Al^{3+}

(Total for question = 1 mark)

Q50.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new

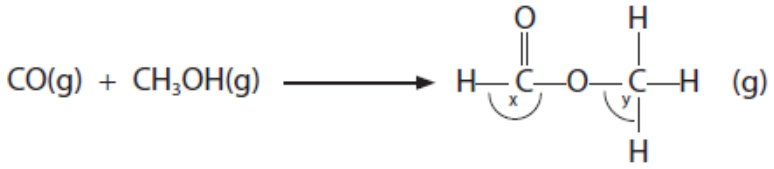
answer with a cross ☒.

A mixture of ethanoic acid, ethanol and a catalyst was left for several days to reach equilibrium.

$$CH_3COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l)$$

The equilibrium constant, K_c, **under these conditions**, was 0.28.

Another ester, methyl methanoate, can be formed by the reaction between methanol and carbon monoxide in the gaseous phase.



(i) The two O−C−H bond angles, x and y, in the ester are approximately

(1)

☒ **A** 180° and 90°

☒ **B** 120° and 90°

☒ **C** 120° and 109.5°

☒ **D** 109.5° and 109.5°

(ii) The reaction often forms an equilibrium mixture.

Which could be the units for the equilibrium constant, K_p?

(1)

☒ **A** mol dm^{-3}

☒ **B** dm^3 mol^{-1}

☒ **C** atm

☒ **D** atm^{-1}

(iii) Describe what effect, if any, increasing the pressure would have on the equilibrium constant, K_p. Justify your answer.

(2)

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(Total for question = 4 marks)

Q51.

This question is about methanol, CH_3OH .

Methanol is soluble in water.

(i) State the strongest type of intermolecular force that occurs between molecules of methanol and water.

(1)

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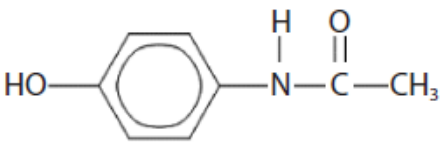
(ii) Draw a labelled diagram to show the interaction named in (i) between one molecule of methanol and one
molecule of water.
Include any relevant lone pairs and dipoles in your diagram.

(3)

(Total for question = 4 marks)

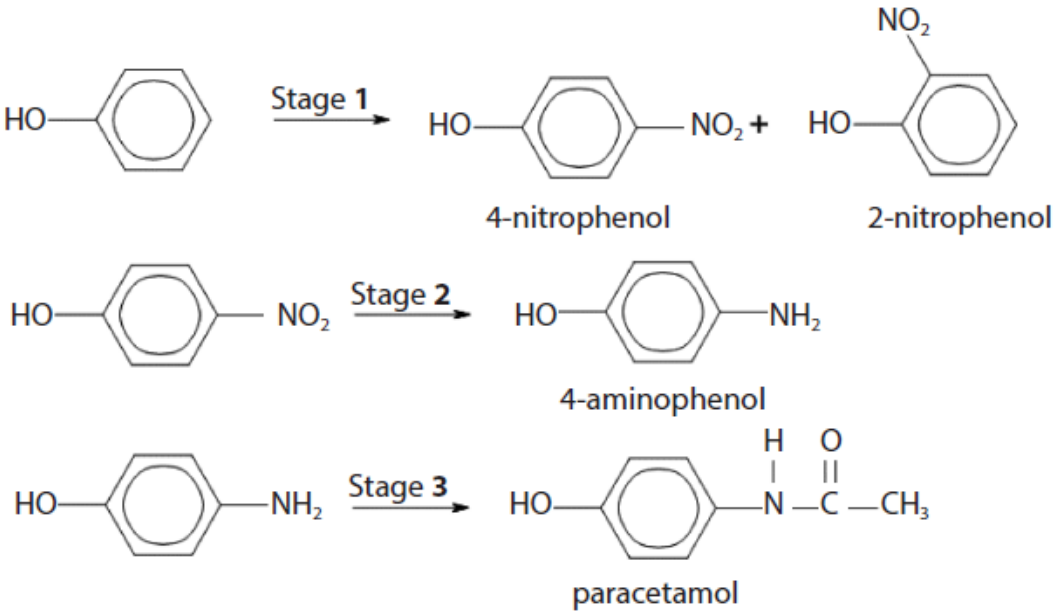
Q52.

This question is about the preparation and analysis of paracetamol.



paracetamol

Paracetamol may be prepared from phenol in three stages.



In Stage **1**, phenol is nitrated using dilute nitric acid.

The nitration of benzene requires concentrated nitric acid at 55°C with a catalyst of concentrated sulfuric acid.
Both these reactions are electrophilic substitution.

(i) Explain why phenol can be nitrated using milder conditions than benzene.

(2)

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(ii) A mixture of 2-nitrophenol and 4-nitrophenol is produced in Stage **1**.
They are separated by steam distillation.

The boiling temperature of 2-nitrophenol is 215°C and that of 4-nitrophenol is 279°C.

Explain, in terms of intermolecular forces, why 4-nitrophenol has a higher boiling temperature than 2-nitrophenol.
You may include a diagram in your answer.

(2)

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(Total for question = 4 marks)

Q53.

Sodium tetrahydridoborate(III), $NaBH_4$, is used in organic chemistry.
It is an alternative reagent to lithium tetrahydridoaluminate(III) for the reduction of carbonyl compounds.

(i) Draw a dot-and-cross diagram of the BH_4^- ion.

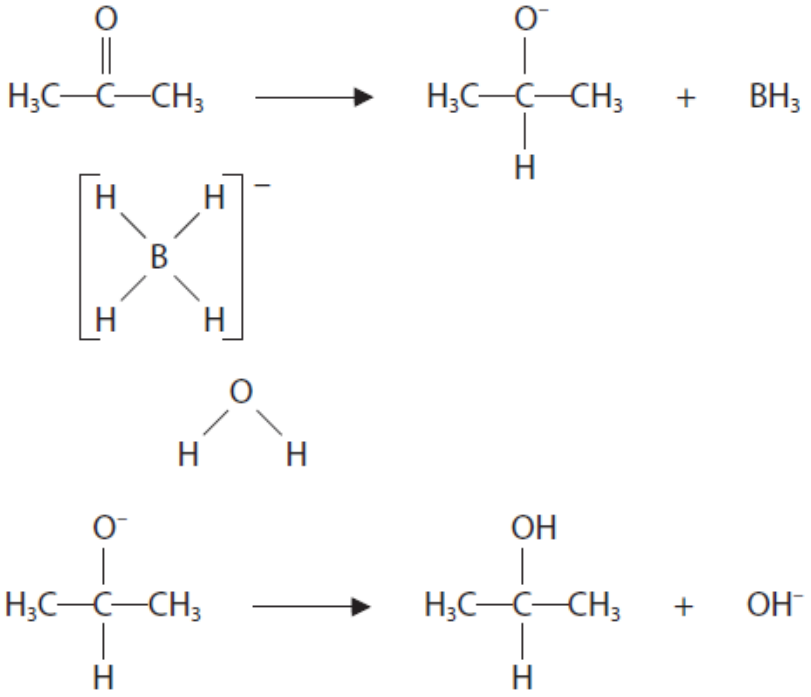
Use crosses (×) for the boron electrons, dots (•) for the hydrogen electrons and triangles (Δ) for the additional electron forming the negative ion.

(1)

(ii) The BH_4^- ions reduce carbonyl compounds to alcohols in aqueous solution.

Complete the mechanism for the reduction of propanone to propan-2-ol by adding curly arrows, and any relevant lone pairs and dipoles.

(4)



(Total for question = 5 marks)

Q54.

This question is about shapes of molecules.

(i) Which of these pairs of molecules have similar shapes?

(1)

☒ **A** $AlCl_3$ and BCl_3

☒ **B** $AlCl_3$ and PCl_3

☒ **C** BCl_3 and NH_3

☒ **D** $BeCl_2$ and H_2O

(ii) The chlorine atom in chlorine trifluoride, ClF_3, is surrounded by three bonding pairs of electrons and two lone pairs of electrons.

Draw two possible shapes for the ClF_3 molecule, showing the positions of the lone pairs of electrons.

(2)

Shape 1

Shape 2

(iii) Explain, using the electron pair repulsion theory, which of the two shapes is more likely to be the correct shape of the ClF_3 molecule.

(2)

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Q55.

This question is about intermolecular forces.

(a) Which solid structure consists of particles held together by London forces only?

(1)

☒ **A** 2-aminoethanoic acid

☒ **B** copper

☒ **C** iodine

☒ **D** silicon(IV) oxide

(b) Ionic oxides and giant covalent oxides are used in the manufacture of fibreglass.
Which oxide is **not** a constituent of fibreglass?

(1)

☒ **A** Al_2O_3

☒ **B** MgO

☒ **C** P_4O_{10}

☒ **D** SiO_2

(c) Which statement describes a phenomenon that can be explained by the existence of intermolecular hydrogen bonding?

(1)

☒ **A** the boiling temperatures of the alkanes increase with increasing relative molecular mass

☒ **B** hydrogen bromide has a higher boiling temperature than hydrogen chloride

☒ **C** CH_3COCH_3 has a higher boiling temperature than $CH_3CH_2CH_2CH_3$

☒ **D** ice has a lower density than water at 0 °C