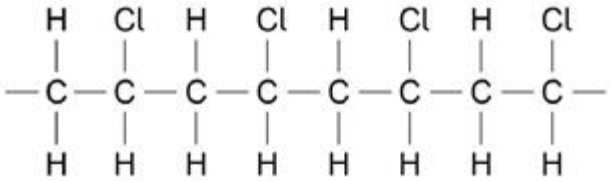
Q20.

Chloroethene can be polymerised to form poly(chloroethene), commonly known as PVC. This polymer can be used to make pipes, window frames and electrical insulation. Plasticisers can be added to change the properties of PVC

A section of poly(chloroethene) is shown.



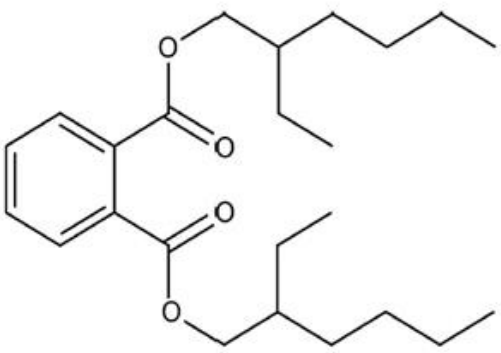
(a) Chloroethene has a melting point of −154 °C

All types of PVC melt at temperatures over 100 °C

Explain why PVC melts at a higher temperature than chloroethene.

(2)

(b) This structure shows a molecule that has been used as a plasticiser in PVC.



Deduce the number of hydrogen atoms in this molecule.

(1)

(c) Use your understanding of the properties of PVC to explain whether you would expect to find a plasticiser in the PVC used to insulate electrical cables.

_____

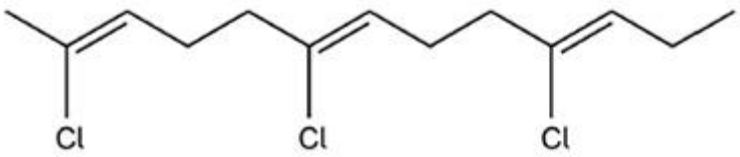
_____

_____

_____

(1)

(d) A section of the polymer poly(chloroprene), a synthetic rubber, is shown.



Draw the **displayed** formula for the repeating unit of poly(chloroprene).

(1)

(Total 5 marks)

Q21.

Which compound has the highest boiling point?

A $CH_3CH_2CH_2OH$ ⬭

B CH_3CH_2CHO ⬭

C CH_3COCH_3 ⬭

D CH_3COOCH_3 ⬭

(Total 1 mark)

Q22.

This question is about elements in Group 7 of the Periodic Table and their compounds.

(a) Bromine (Br_2), strontium chloride ($SrCl_2$) and iodine monochloride (ICl) all have similar M_r values.

Suggest, with reasons, the order of melting points for these three substances.

(6)

(b) Write an equation for the reaction of chlorine with cold water.

State a reason why chlorine is added to drinking water, and suggest a disadvantage of treating water in this way.

Equation

Reason

Disadvantage

(3)

(c) Bromine reacts with phosphorus to form phosphorus tribromide.

Write an equation for this reaction and draw the shape of the phosphorus tribromide molecule formed.

Suggest the bond angle in phosphorus tribromide.

Equation

_____

Shape

Bond angle _____

(3)

(d) Phosphorus pentabromide in the solid state consists of PBr_4^+ and Br^- ions.

Draw the shape of the PBr_4^+ ion and suggest its bond angle.

Shape

Bond angle _____

(2)

(Total 14 marks)

Q23.

Halogenoalkanes such as 1,1,2-trichloro-1,2,2-trifluoroethane were used as coolants in refrigerators until the late 1980s. Their use was then banned and alternative coolants were used instead.

(a) Draw the displayed formula of 1,1,2-trichloro-1,2,2-trifluoroethane.

(1)

(b) 1,1,2-Trichloro-1,2,2-trifluoroethane was banned for use as a refrigerant because it damaged the ozone layer.

Write **three** equations to show how this compound is involved in damaging the ozone layer.

_____

_____

_____

(3)

(c) State the role of chlorine atoms in the reactions in part **(b)**.

_____

(1)

(d) Inevitably, some coolant escapes from refrigerators.

Deduce which of the following coolants, **A**, **B** or **C**, would cause least environmental damage to the atmosphere.

$CHCl_2CHClF$	CF_3CH_2F	CF_3CCl_2F
A	**B**	**C**

Coolant _____

(1)

(e) Give the IUPAC name of compound **B** in part **(d)**.

_____

(1)

(f) The boiling point of iodomethane (CH_3I) is higher than that of fluoromethane (CH_3F) even though the electronegativity of iodine is less than that of fluorine.

Explain why iodomethane has the higher boiling point by considering the forces that act between CH_3I molecules and comparing these forces with the forces between the CH_3F molecules.

_____

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

Q24.

This question is about the element iodine and its compounds.

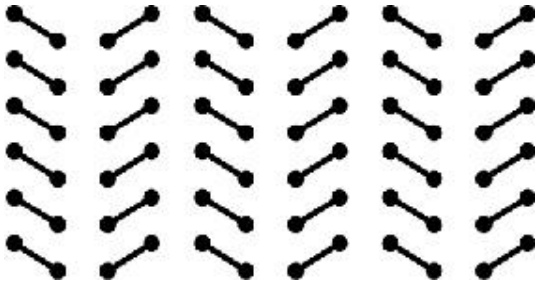
(a) Iodine is in Group 7 of the Periodic Table.

Complete the electron configuration of an iodine atom.

[Kr] _____

(1)

(b) Part of the structure of an iodine crystal is shown in the diagram.



Use your knowledge of structure and bonding to explain why the melting point of iodine is low (113.5 °C) and why that of hydrogen iodide is very low (–50.8 °C).

(6)

(c) State why iodine does **not** conduct electricity.

_____

_____

_____

(1)

(d) Deduce an equation for the formation of hydrogen iodide from its elements.

_____

(1)

(e) The triiodide ion is formed when an iodine molecule is bonded to an iodide ion.

What is the formula of ammonium triiodide?

Tick (✓) **one** box.

NH_3I_3 ☐

NH_3I_4 ☐

NH_4I ☐

NH_4I_3 ☐

(1)

(f) Draw the shape of the IF_3 molecule and the shape of the IF_4^- ion.
Include any lone pairs of electrons that influence each shape.

(2)

(g) Deduce the oxidation state of iodine in the following species.

$Ba(IO_3)_2$ _____

$[H_4IO_6]^-$ _____

(2)

(Total 14 marks)

Q25.

Which statement about intermolecular forces is **not** correct?

A	Intermolecular forces exist between all simple molecules.	⬭
B	Hydrogen bonding occurs between HBr molecules.	⬭
C	Hydrogen bonding is the strongest intermolecular force in liquid ethanol.	⬭
D	Hydrogen bonds occur between C=O and H−N in proteins.	⬭

(Total 1 mark)

Q26.

Use your understanding of intermolecular forces to predict which of these compounds has the highest boiling point.

A	HF	⬭
B	HCl	⬭
C	HBr	⬭
D	HI	⬭

(Total 1 mark)

Q27.

Which of these substances does **not** show hydrogen bonding?

A	HF	⬭
B	NH_3	⬭
C	CH_3COOH	⬭
D	CHF_3	⬭

(Total 1 mark)

Q28.

Which of these substances has permanent dipole-dipole attractions between molecules?

A CCl_4 ⬭

B C_2F_4 ⬭

C $(CH_3)_2CO$ ⬭

D CO_2 ⬭

(Total 1 mark)

Q29.

The table below contains some entropy data relevant to the reaction used to synthesise methanol from carbon dioxide and hydrogen. The reaction is carried out at a temperature of 250 °C.

Substance	$CO_2(g)$	$H_2(g)$	$CH_3OH(g)$	$H_2O(g)$
Entropy ($S^\ominus$) / J K^{-1} mol^{-1}	214	131	238	189

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \quad \Delta H = -49 \text{ kJ mol}^{-1}$$

(a) Use this enthalpy change and data from the table to calculate a value for the free-energy change of the reaction at 250 °C.
Give units with your answer.

Free-energy change = _____ Units = _____

(4)

(b) Calculate a value for the temperature when the reaction becomes feasible.

Temperature = _____ K

(2)

(c) Gaseous methanol from this reaction is liquefied by cooling before storage.

Draw a diagram showing the interaction between two molecules of methanol. Explain why methanol is easy to liquefy.

Diagram

Explanation _____

_____

_____

(4)

(Total 10 marks)

Q30.

Ethanol can be oxidised by acidified potassium dichromate(VI) to ethanoic acid in a two-step process.

ethanol ⟶ ethanal ⟶ ethanoic acid

(a) In order to ensure that the oxidation to ethanoic acid is complete, the reaction is carried out under reflux.

Describe what happens when a reaction mixture is refluxed and why it is necessary, in this case, for complete oxidation to ethanoic acid.

(3)

(b) Write a half-equation for the overall oxidation of ethanol into ethanoic acid.

(1)

(c) The boiling points of the organic compounds in a reaction mixture are shown in the following table.

Compound	ethanol	ethanal	ethanoic acid
Boiling point / °C	78	21	118

Use these data to describe how you would obtain a sample of ethanal from a mixture of these three compounds. Include in your answer a description of the apparatus you would use and how you would minimise the loss of ethanal. Your description of the apparatus can be either a description in words or a labelled sketch.

(5)

(d) Use your knowledge of structure and bonding to explain why it is possible to separate ethanal in this way.

(2)

(e) A student obtained a sample of a liquid using the apparatus in part **(c)**.

Describe how the student could use chemical tests to confirm that the liquid contained ethanal and did **not** contain ethanoic acid.

(5)

(Total 16 marks)

Q31.

Which compound has the highest boiling point?

A C_2H_4 ⬭

B C_2H_6 ⬭

C CH_3NH_2 ⬭

D CH_3F ⬭

(Total 1 mark)

Mark Scheme

Q20.

(a) **M1** it / PVC is bigger/longer molecule / has more electrons / has bigger surface area / greater M_r

1

M2 it / PVC has stronger (van der Waals' / dipole-dipole) forces <u>between molecules</u> / <u>intermolecular</u> forces

1

__M1__ and __M2__ independent of each other

CE = 0 if reference to hydrogen bonds or breaking of covalent bonds when substances are melted

Comparison must be implied in __M1__ or __M2__ to score 2 marks

If there is no comparison at all, then 1 mark could score either for explaining that PVC has strong <u>intermolecular</u> forces due to being a big/long molecule / having many electrons / large surface area / large M_r, or, for explaining that chloroethene has weak <u>intermolecular</u> forces due to being a small/short molecule / having few electrons / low surface area / low M_r,

(b) 38

ignore additional words

1

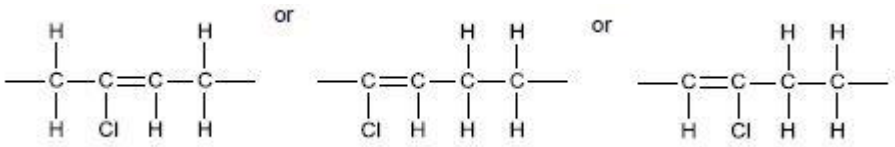
(c) Need both ideas that

- it is present AND
- because PVC needs to be flexible / bendy

penalise incorrect properties

1

(d) Displayed structure required



ignore any bracket or n

1

[5]

Q21.

A

[1]

Q22.

(a) $SrCl_2$> ICl > Br>

If wrong can award 1 for one in the correct 'position'

2

$SrCl_2$ strong ionic bonds / (strong electrostatic attraction between opposite ions)

1

Lattice so many strong bonds to overcome

1

ICl has dipole-dipole between molecules – weaker than ionic bonds

1

Br_2 has van der Waals forces between molecules – much weaker

Accept London / dispersion / induced dipole forces

1

(b) $Cl_2 + H_2O \rightleftharpoons HCl + HClO$

OR $2Cl_2 + 2H_2O \rightleftharpoons O_2 + 4HCl$

OR $Cl_2 + H_2O \rightleftharpoons 2H^+ + Cl^- + ClO^-$

1

Kills bacteria

1

Wasteful as most potable water not used for drinking - used in washing clothes etc

OR Some people suffer eye irritation / Some people find the taste unpleasant

OR can react with organic compounds to produce harmful substances

Allow 'it is potentially toxic as it can be if over concentrated'

1

(c) $6Br_2 + P_4 \longrightarrow 4PBr_3$

Accept 4P for P_4

1

Pyramidal shown in a diagram (but the name of the shape isn't needed)

1

100–108°

Actual value is 101° (hence larger range of values allowed)

1

(d) Tetrahedral shown in a diagram (but the name of the shape isn't needed)

1

109.5°

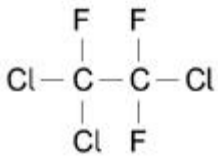
Accept 109° or 109°28'

1

[14]

Q23.

(a)



1

(b) Initiation: $CCl_2FCF_2Cl \longrightarrow Cl\bullet + CCl_2FCF_2\bullet$.

Allow initiation equations where more than one Cl• is formed

1

$Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$

1

$ClO\bullet + O_3 \longrightarrow 2O_2 + Cl\bullet$

1

(c) Acts as a catalyst

1

(d) B

1

(e) 1,1,1,2-tetrafluoroethane

1

(f) Iodine is bigger than fluorine so the van der Waals forces between CH_3I molecules are stronger than those between CH_3F molecules

1

The dipole-dipole forces between CH_3F molecules are stronger than those between CH_3I molecules

Or vice versa

1

The van der Waals forces are stronger than the dipole-dipole forces so these dominate

1

[10]

Q24.

(a) $[Kr]\ 5s^2\ 4d^{10}5p^5$

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3
All stages are covered and the explanation of each stage is correct and complete.

Answer communicates the whole explanation coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

5-6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3-4 marks

Level 1
Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1-2 marks

Level 0
Insufficient correct chemistry to warrant a mark.

0 marks

Indicative Chemistry content

Stage 1

I_2 is molecular.

HI is molecular.

Stage 2

IMF hold the molecules together.

There are weak IMF forces hence the melting point is low in both substances.

I_2 bigger molecule than HI so I_2 has more electrons.

Stage 3

Therefore stronger van der Waals between molecules in I_2 that need more energy to break causing the melting point to be higher.

HI also shows permanent dipole-dipole attraction between molecules but these forces are less than the vdW forces in iodine.

6

(c) No delocalised electrons or ions

1

(d) $\frac{1}{2}H_2 + \frac{1}{2}I_2 \longrightarrow HI$

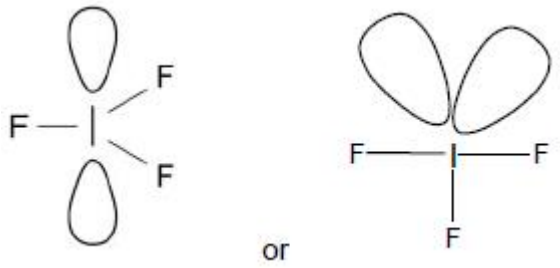
Allow multiples

1

(e) NH_4I_3

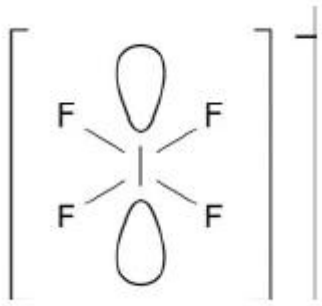
1

(f)



Allow any shape with 3 bond pairs and 2 lone pairs

1



Allow any shape with 4 bond pairs and 2 lone pairs (e.g. lone pairs in equatorial positions)

1

(g) +5

1

+7

1

[14]

Q25.

B

[1]

Q26.

A

[1]

Q27.

D

[1]

Q28.

C

[1]

Q29.

(a) $\Delta S = 238 + 189 - 214 - 3 \times 131 = -180$ J K^{-1} mol^{-1}

1

$\Delta G = \Delta H - T\Delta S$

1

$= -49 - \frac{523 \times (-180)}{1000}$

1

$= +45.1$ kJ mol^{-1}

Units essential

1

(b) When $\Delta G = 0$, $\Delta H = T\Delta S$ therefore $T = \Delta H / \Delta S$

1

$= -49 \times 1000 / -180 = 272$ (K)

Mark consequentially to ΔS in part (a)

1

(c) Diagram marks

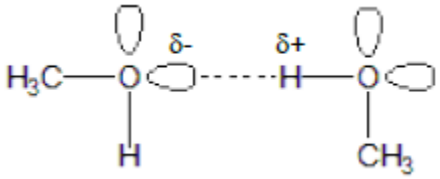


Diagram of a molecule showing O–H bond and two lone pairs on each oxygen

1

Labels on diagram showing δ+ and δ- charges

Allow explanation of position of δ+ and δ- charges on H and O

1

Diagram showing δ+ hydrogen on one molecule attracted to lone pair on a second molecule

1

Explanation mark

Hydrogen bonding (the name mentioned) is a strong enough force (to hold methanol molecules together in a liquid)

1

[10]

Q30.

(a) A mixture of liquids is heated to boiling point for a prolonged time

1

Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture

1

Any ethanal and ethanol that initially evaporates can then be oxidised

1

(b) $CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$

1

(c) Mixture heated in a suitable flask / container

A labelled sketch illustrating these points scores the marks

1

With still head containing a thermometer

1

Water cooled condenser connected to the still head and suitable cooled collecting vessel

1

Collect sample at the boiling point of ethanal

1

Cooled collection vessel necessary to reduce evaporation of ethanal

1

(d) Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in ethanal

1

Intermolecular forces / dipole-dipole are weaker than hydrogen bonding

1

(e) Reagent to confirm the presence of ethanal:

Add Tollens' reagent / ammoniacal silver nitrate / aqueous silver nitrate followed by 1 drop of aqueous sodium hydroxide, then enough aqueous ammonia to dissolve the precipitate formed

OR

Add Fehling's solution

1

Warm

M2 and M3 can only be awarded if M1 is given correctly

1

Result with Tollen's reagent:

Silver mirror / black precipitate

OR

Result with Fehling's solution:

Red precipitate / orange-red precipitate

1

Reagent to confirm the absence of ethanoic acid

Add sodium hydrogencarbonate or sodium carbonate

1

Result; no effervescence observed; hence no acid present

1

M5 can only be awarded if M4 is given correctly

OR

Reagent; add ethanol and concentrated sulfuric acid and warm

Result; no sweet smell / no oily drops on the surface of the liquid,

hence no acid present

[16]

Q31.

C

[1]