Q1.

Use

3 **(a)** The melting points of some oxides of Group IV elements are given below.

oxide	melting point / °C
CO_2	–78
SiO_2	1610
SnO_2	1630

Describe the bonding in each oxide, and how it relates to its melting point.

(i) CO_2

.....

.....

.....

(ii) SiO_2

.....

.....

.....

(iii) SnO_2

.....

.....

.....

[3]

(b) Writing balanced equations where appropriate, describe how the above three oxides differ in their reactions with

(i) NaOH(aq),

.....

.....

.....

(ii) HCl(aq).

.....

.....

.....

[4]

(c) The last oxide in Group IV, PbO_2, reacts with concentrated hydrochloric acid liberating chlorine gas.

Use the *Data Booklet* to calculate the $E^{\ominus}_{cell}$ and to write a balanced equation for this reaction.

.....

.....[2]

[Total : 9]

Q2.

2 All the Group IV elements form chlorides with the formula MCl_4.

(a) Describe the bonding in, and the shape of, these chlorides.

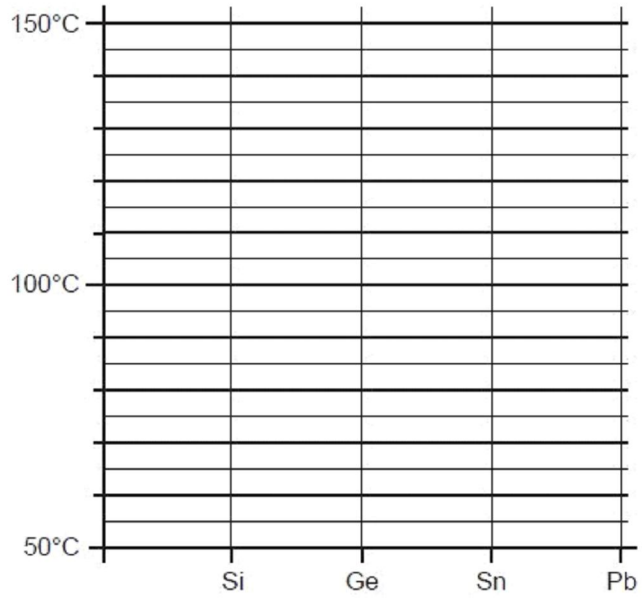
(i) bonding .....

(ii) shape .....[2]

The boiling point of lead(IV) chloride cannot be measured directly because it decomposes on heating. The following table lists the boiling points of three Group IV chlorides.

chloride	b.p. / °C
$SiCl_4$	58
$GeCl_4$	83
$SnCl_4$	114

(b) (i) Plot these data on the following axes and extrapolate your graph to predict what the boiling point of $PbCl_4$ would be if it did not decompose.



(ii) Suggest why the boiling points vary in this way.

.....

.....

.....[4]

Use

(c) $SiCl_4$ reacts vigorously with water whereas CCl_4 is inert.

(i) Suggest a reason for this difference in reactivity.

.....

(ii) Write an equation for the reaction between $SiCl_4$ and water.

.....

(iii) Suggest, with a reason, whether you would expect $GeCl_4$ to react with water.

.....

.....

[3]

(d) $SiCl_4$ is used to make high-purity silicon for the semiconductor industry. After it has been purified by several fractional distillations, it is reduced to silicon by heating with pure zinc.

(i) Suggest an equation for the reduction of $SiCl_4$ by zinc.

.....

(ii) Use your equation to calculate what mass of zinc is needed to produce 250 g of pure silicon by this method.

mass of zinc = ... g [3]

[Total: 12]

Q3.

Use

3 Carbon forms two stable oxides, CO and CO_2. Lead forms three oxides: yellow PbO, black PbO_2 and red Pb_3O_4.

(a) Carbon monoxide burns readily in air. Heating black lead oxide produces oxygen gas, leaving a yellow residue.

(i) Suggest a balanced equation for **each** reaction.

.....

.....

(ii) Explain how these two reactions illustrate the relative stabilities of the +2 and +4 oxidation states down Group IV.

.....

.....

[3]

(b) Red lead oxide contains lead atoms in two different oxidation states.

(i) Suggest what these oxidation states are, and calculate the ratio in which they occur in red lead oxide.

.....

.....

(ii) Predict the equation for the action of heat on red lead oxide.

.....

When red lead oxide is heated with dilute nitric acid, HNO_3, a solution of lead(II) nitrate is formed and a black solid is left.

(iii) Suggest an equation for this reaction.

.....

(iv) Explain how this reaction illustrates the relative basicities of the two oxidation states of lead.

.....

.....

[5]

(c) Both tin(II) oxide and tin(IV) oxide are amphoteric.

Write a balanced equation for the reaction between tin(II) oxide and aqueous sodium hydroxide.

.....[1]

[Total: 9]

Q4.

3 The elements of Group IV all form tetrachlorides with the general formula MCl_4.

(a) Draw a diagram of a molecule of $SiCl_4$ stating bond angles.

[2]

(b) Describe and explain how the volatilities of the Group IV chlorides vary down the group.

.....

.....

..... [2]

(c) The relative stabilities of the $M^{2+}(aq)$ and $M^{4+}(aq)$ ions also vary down Group IV.

(i) Use the *Data Booklet* to illustrate this observation when M = Sn and M = Pb.

.....

.....

.....

(ii) Use the *Data Booklet* to predict the products formed, and write equations for the reactions occurring, when

- an equimolar mixture of $Sn^{2+}(aq)$ and $Sn^{4+}(aq)$ is added to $I_2(aq)$,

.....

.....

- an equimolar mixture of $Pb^{2+}(aq)$ and $Pb^{4+}(aq)$ is added to $SO_2(aq)$.

.....

.....

[4]

Use

(d) **(i)** The Sn–C*l* bond energy is +315 kJ mol^{-1}. Use this and other values from the *Data Booklet* to calculate $\Delta H^{\ominus}$ for the reaction

$$MCl_2(g) + Cl_2(g) \rightarrow MCl_4(g)$$

for the following cases.

- M = Si

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

- M = Sn

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

(ii) Do your results agree with the trend in relative stabilities of the +2 and +4 oxidation states in **(c)**? Explain your answer.

.....

.....

.....

[3]

[Total: 11]

Q5.

3 **(a)** Describe how the behaviour of the oxides of tin and lead in their +4 oxidation states differ on heating.

For Examiner Use

.....

.....[1]

(b) Explain the following by using data from the *Data Booklet* where appropriate, and writing equations for all reactions.

(i) A sample of liquid $PbCl_4$ is placed in a flask and the flask is gently warmed. A gas is evolved and a white solid is produced. When the gas is bubbled through KI(aq), purple fumes are produced.

.....

.....

.....

.....

(ii) Repeating the same experiment using liquid $SnCl_4$ instead of $PbCl_4$ results in no evolution of gas, and no reaction with KI(aq).

.....

.....
[4]

(c) The molecule dichlorocarbene, CCl_2, can be produced under certain conditions. It is highly unstable, reacting with water to produce carbon monoxide and a strongly acidic solution.

(i) Suggest the electron arrangement in CCl_2 and draw a dot-and-cross diagram showing this. Predict the shape of the molecule.

(ii) Construct an equation for the reaction of CCl_2 with water.

.....
[3]

[Total: 8]

Q6.

3 **(a)** Fluorine is much more electronegative than both silicon and sulfur, but whereas the molecule of SF_4 has an overall dipole, that of SiF_4 has none.

For Examiner's Use

Suggest a reason for this difference.

.....

.....[1]

(b) Predict whether or not the following molecules will have an overall dipole. Place a tick in the appropriate column.

compound	molecule has an overall dipole	molecule does not have an overall dipole
BCl_3		
PCl_3		
CCl_4		
SF_6		

[2]

(c) Boron and silicon are two elements adjacent to carbon in the periodic table. CCl_4 does not react with water, whereas BCl_3 and $SiCl_4$ do react.

(i) Suggest a reason for this difference in reactivity.

.....

.....

(ii) Construct equations showing the reaction of these two chlorides with an excess of water.

BCl_3 .....

$SiCl_4$ .....

[3]

(d) When reacted with a small quantity of water, $SiCl_4$ produces an oxychloride **X**, $Si_xCl_yO_z$. The mass spectrum of **X** shows peaks at mass numbers of 133, 149, 247, 263 and 396. (You should assume that the species responsible for all these peaks contain the ^{16}O, the ^{35}Cl and the ^{28}Si isotopes only.)

For Examiner's Use

(i) Use these data to deduce the molecular formula of **X**.

molecular formula .....

(ii) Suggest the structures of the fragments responsible for the peaks at the following mass numbers.

mass number	structure
133	
247	
263	

(iii) Hence suggest the displayed formula of **X**.

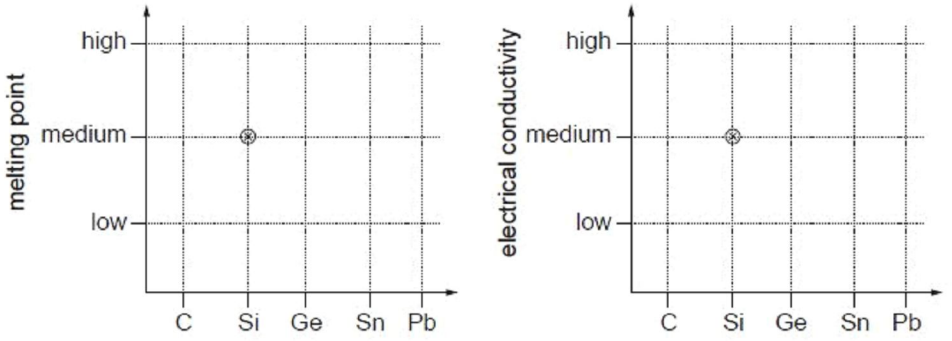
[5]

[Total: 11]

Q7.

2 **(a)** **(i)** On the following grids, plot points showing the variation in the named property of the Group IV elements. Your points should show for each element, whether the melting point/electrical conductivity is 'high', 'medium' or 'low'. The point for silicon has already been plotted in each case.

For Examiner Use



(ii) Suggest explanations of these trends in terms of the structure and bonding of the Group IV elements.

melting point

.....

.....

electrical conductivity

.....

.....

[6]

(b) Choose **one** reaction to illustrate **each** of the following statements. Write an equation for each of your chosen reactions, and describe what you would see as the reaction is carried out.

(i) PbO is more stable than PbO_2.

.....

.....

(ii) CO is easily oxidised to CO_2.

.....

.....

(iii) Aqueous $SnCl_2$ is a useful reducing agent.

.....

.....

[4]

[Total: 10]

Q8.

4 **(a)** **(i)** Describe and explain the trend in the volatilities of the Group IV chlorides CCl_4, $GeCl_4$ and $PbCl_4$.

For Examiner's Use

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.....

.....

(ii) Describe and explain the reactions, if any, of these chlorides with water. Write equations for any reactions that occur.

.....

.....

.....

.....

.....

.....

.....

[7]

For Examiner's Use

(b) SnO_2 and PbO_2 react with acids in different ways.

- SnO_2 reacts with concentrated sulfuric acid to form a colourless solution with no evolution of gas.
- PbO_2 reacts with concentrated sulfuric acid to give a white solid, **B**, and oxygen gas.
- PbO_2 reacts with cold concentrated hydrochloric acid to give a yellow solution containing the $[PbCl_6]^{2-}$ ion, with no evolution of gas.
- Warming this yellow solution causes the evolution of Cl_2 gas, leaving a colourless solution which on cooling in ice precipitates a white solid, **C**.

(i) Identify the two white solids, **B** and **C**, mentioned above.

B .....

C .....

(ii) Suggest an equation for **each** of the four reactions described above.

.....

.....

.....

.....

.....

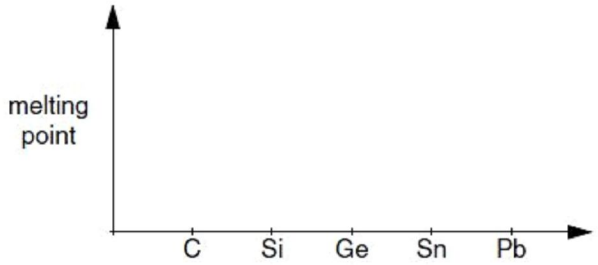
.....

[4]

[Total: 11]

Q9.

3 (a) (i) On the following axes, sketch the variation in melting points of the elements in Goup IV.



[2]

(ii) Explain how this variation in melting point is related to the structure and bonding of the elements.

.....

.....

.....

.....[2]

(b) CCl_4 and $SiCl_4$ behave differently with water.

(i) Describe the reaction (if any) of CCl_4 with water.

.....

(ii) Describe the reaction (if any) of $SiCl_4$ with water.

.....

(iii) Write equations for any reactions that occur.

.....

.....

(iv) Explain why these two chlorides differ in their behaviour with water.

.....

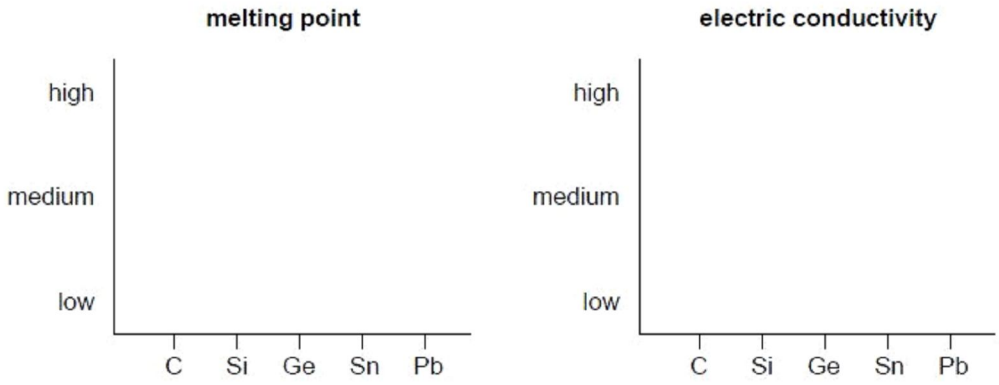
.....

[4]

[Total: 8]

Q10.

3 **(a)** **(i)** Use the following sets of axes to sketch graphs of the variations in the melting points and the electrical conductivities of the Group IV elements.



(ii) Explain how the variation in conductivity is related to the structure and bonding in the elements.

.....

.....

.....

[6]

(b) Going down Group IV there is a variation in the relative stabilities of the higher and lower oxidation states of the elements in their oxides.

Illustrating your answers with balanced chemical equations, in each of the following cases suggest **one** piece of chemical evidence to show that

(i) CO is less stable than CO_2,

.....

.....

(ii) PbO is more stable than PbO_2.

.....

.....

[3]

(c) Name **one** ceramic based on silicon(IV) oxide, and explain what properties of the oxide make it suitable for this use.

.....

..... [1]

(d) Tin(II) oxide reacts with both acids and alkalis.

(i) What name is given to this property of an oxide?

.....

(ii) Write suitable equations to show these two reactions of tin(II) oxide.

.....

.....

[3]

[Total: 13]

Q11.

1 **(a)** Describe and explain how the boiling points of the tetrachlorides of the Group IV elements vary down the group.

.....

.....

.....

..... [3]

(b) The tetrachlorides are all covalent compounds. Draw a diagram showing the shape of a molecule of silicon tetrachloride, including values for bond angles.

[2]

(c) The noble gas xenon forms a tetrafluoride, XeF_4. Only four of xenon's outer shell electrons are used in bonding to the fluorine atoms.

(i) Draw a dot-and-cross diagram showing how the outer-shell electrons are arranged in XeF_4.

(ii) Predict the shape and the bond angles in XeF_4.

.....

.....

[4]

(d) Describe and explain how the reactions of CCl_4 and $SiCl_4$ with water differ. Write an equation for any reaction that occurs.

.....

.....

.....

..... [3]

(e) Many tonnes of lead tetrachloride used to be produced to make the anti-knock petrol additive tetraethyl-lead, $Pb(C_2H_5)_4$, by the following reaction.

$PbCl_4$ + ... Na + ... C_2H_5Cl ⟶ $Pb(C_2H_5)_4$ + ... $NaCl$

Balance this equation and use it to calculate the mass of sodium needed to produce 1.0 kg of tetraethyl-lead.

.....

.....

..... [3]

[Total: 15]

Q12.

4 **(a)** By choosing the chlorides of **two** of the Group IV elements as examples, describe the trend in the reactions of these chlorides with water. Suggest an explanation for any differences, and write equations for any reactions that occur.

.....

.....

.....

.....[3]

(b) The standard enthalpy changes of formation of lead(II) chloride and lead(IV) chloride are given in the following table.

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$PbCl_2(s)$	–359
$PbCl_4(l)$	–329

Use these data, and also bond energy data from the *Data Booklet*, to calculate the enthalpy changes for the following two reactions.

(i) $CCl_2(g) + Cl_2(g) \longrightarrow CCl_4(g)$

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

(ii) $PbCl_2(s) + Cl_2(g) \longrightarrow PbCl_4(l)$

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

(iii) Make use of your answers to parts **(i)** and **(ii)** to suggest how the relative stabilities of the two oxidation states vary down the Group.

.....

.....

[3]

[Total: 6]

Q13.

4 The most typical oxides of tin and lead are SnO, SnO_2, PbO and PbO_2.

The following two generalisations can be made about the oxides of the elements in Group IV.

- As the metallic character of the elements increases down the Group, the oxides become more basic.
- The oxides of the elements in their higher oxidation states are more acidic than the oxides of the elements in their lower oxidation states.

(a) Use these generalisations to suggest which of the above oxides of tin or lead is **most likely** to react with each of the following reagents. In each case write a balanced equation for the reaction.

(i) with NaOH(aq)

formula of oxide .....

equation .....

(ii) with HC*l*(aq)

formula of oxide .....

equation .....

[4]

(b) 'Red lead' is used as a pigment, and as a metal primer paint to prevent the corrosion of steel. It is an oxide of lead that contains 9.30% oxygen by mass.

Calculate to **3 significant figures** the number of moles of oxygen and lead contained in a 100.0 g sample of red lead. Hence calculate its empirical formula.

empirical formula: ..... [2]

(c) Lead(II) chloride is slightly soluble in water.

For Examiner's Use

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq) \qquad K_{sp} = 2.0 \times 10^{-5}$$

(i) Write an expression for the solubility product, K_{sp} for lead(II) chloride and state its units.

K_{sp} = ... units .....

(ii) Calculate $[Pb^{2+}(aq)]$ in a saturated solution of $PbCl_2$.

.....

.....

An excess of $PbCl_2(s)$ is stirred with 0.50 mol dm^{-3} NaCl until equilibrium has been established. The excess $PbCl_2(s)$ is then filtered off.

(iii) Assuming $[Cl^-]$ remains at 0.50 mol dm^{-3} throughout, calculate the $[Pb^{2+}(aq)]$ in the remaining solution.

.....

.....

(iv) Suggest an explanation for the difference between this value and the value that you calculated in **(ii)**.

.....

[4]

[Total: 10]

Q14.

8 (a) (i) By means of a clear, labelled diagram, describe the shape of the tin(IV) chloride molecule.

For Examiner Use

(ii) Explain the shape of the tin(IV) chloride molecule in terms of its bonding.

.....

.....

[2]

(b) (i) What would you expect to observe when tin(IV) chloride reacts with water? Suggest an explanation for your answer.

.....

.....

.....

(ii) Write an equation for the reaction between tin(IV) chloride and water.

.....

[3]

[Total: 5]

Q15.

2 **(a)** The melting points of some Group IV elements are given below.

element	melting point / K
C	3925
Si	1683
Ge	1210
Sn	505

Suggest an explanation for each of the following.

(i) The melting point of silicon is less than that of carbon.

.....

.....

(ii) The melting point of tin is less than that of germanium.

.....

.....

[2]

(b) Using data from the *Data Booklet* where appropriate, write equations for the following reactions of compounds of Group IV elements.

(i) $SiCl_4(l) + H_2O(l)$

.....

(ii) the action of heat on $PbCl_4(l)$

.....

(iii) $SnCl_2(aq) + FeCl_3(aq)$

.....

(iv) $SnO_2(s) + NaOH(aq)$

.....

[4]

[Total: 6]

Q16.

4 **(a)** The electrical conductivities of some Group IV elements are given below.

element	electrical conductivity / $\Omega^{-1}\,cm^{-1}$
C (graphite)	6.1×10^{2}
Si	2.5×10^{-6}
Ge	1.5×10^{-2}
Sn	9.2×10^{4}

From a consideration of the structures, suggest reasons for the following.

(i) The electrical conductivity of silicon is less than that of graphite.

.....

.....

(ii) The electrical conductivity of tin is more than that of germanium.

.....

.....

[2]

(b) Using data from the *Data Booklet* where appropriate, write equations for the following reactions of compounds of Group IV elements.

(i) the action of heat on $PbO_2(s)$

.....

(ii) $PbO_2(s) + HCl(aq)$

.....

(iii) $SnO(s) + NaOH(aq)$

.....

(iv) $GeCl_4(l) + H_2O(l)$

.....

[4]

[Total: 6]