The Periodic Table: Chemical Periodicity

Question Paper 6

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	The Periodic Table: Chemical Periodici
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 6

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 The following account describes the preparation of Péligot's salt, named after the 19th century French chemist who first made it.

Place 6.0 g of potassium dichromate(VI) in a 100 cm^3 beaker and add 8.0 g of concentrated hydrochloric acid and 1.0 cm^3 water. Warm the mixture gently; if carefully done the dichromate(VI) will dissolve without the evolution of chlorine. On cooling the beaker in an ice bath the solution will deposit long orange-red crystals of Péligot's salt.

An analysis of Péligot's salt showed that it contained the following percentages by mass:
K, 22.4%; Cr, 29.8%; C*l*, 20.3%; O, 27.5%.

(a) Calculate the empirical formula of Péligot's salt.

[2]

(b) Suggest a balanced equation for the formation of Péligot's salt.

.....[1]

(c) The instructions suggest that strong heating might cause chlorine to be evolved.

(i) What *type of reaction* would produce chlorine in this system?

.....

(ii) Use the *Data Booklet* to identify relevant half equations and $E^{\ominus}$ values for the production of chlorine from the reaction between $K_2Cr_2O_7$ and HC*l*.

.....

.....

Use these equations to write the overall full ionic equation for this reaction.

.....

(iii) The use of **dilute** HC*l*(aq) does not result in the production of chlorine. Suggest why this is so.

.....

(iv) Use the *Data Booklet* to suggest a reason why it is **not** possible to prepare the bromine analogue of Péligot's salt by using HBr(aq) instead of HC*l*(aq).

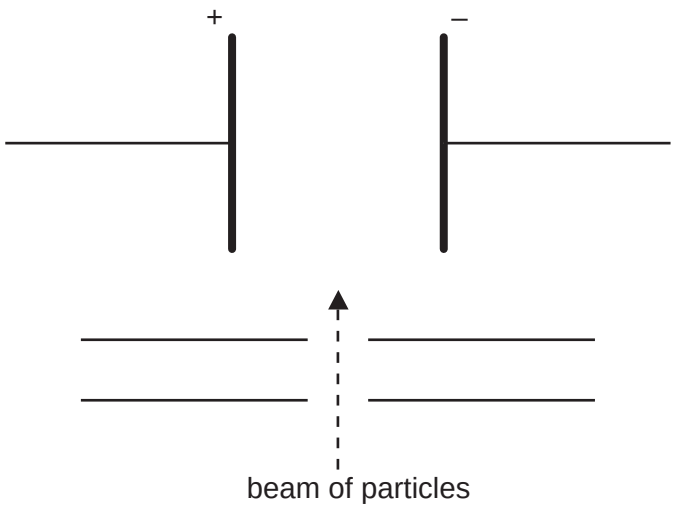
.....

[6]

[Total: 9]

2 In the 19th and 20th centuries, scientists established the atomic theory and showed that three sub-atomic particles, electron, neutron and proton, exist. The masses and charges of these three particles were subsequently determined.

When separate beams of electrons, neutrons or protons are passed through an electric field in the apparatus below, they behave differently.



(a) (i) Which of these three particles will be deflected the most by the electric field?

.....

(ii) In which direction will this particle be deflected?

.....

(iii) Explain your answer.

.....

.....

[4]

(b) (i) Define the term *proton number*.

.....

.....

(ii) Why is the proton number of an atom of an element usually different from the nucleon number of an atom of the element?

.....

.....

[2]

(c) Protons and neutrons have been used in nuclear reactions which result in the formation of artificial elements. In such processes, protons or neutrons are accelerated to high speeds and then fired like 'bullets' at the nucleus of an atom of an element.

Suggest why neutrons are more effective than protons as 'nuclear bullets'.

.....

..... [2]

(d) In some cases, when neutrons are fired at atoms of an element, the neutrons become part of the nucleus of those atoms.

What effect does the presence of an extra neutron have on the chemical properties of the new atoms formed? Explain your answer.

.....

.....

..... [2]

[Total: 10]

3 The first six ionisation energies of an element **X** are given below.

ionisation energy / kJ mol^{-1}					
first	second	third	fourth	fifth	sixth
950	1800	2700	4800	6000	12300

(a) Define the term *first ionisation energy*.

.....

.....

.....

..... [3]

(b) Write an equation, with state symbols, for the **second** ionisation energy of element **X**.

..... [2]

(c) Use the data given above to deduce in which Group of the Periodic Table element **X** is placed. Explain your answer.

Group .....

explanation .....

.....

.....

..... [3]

The first ionisation energies (I.E.) for the elements of Group IV are given below.

element	C	Si	Ge	Sn	Pb
1st I.E. / kJ mol^{-1}	1090	786	762	707	716

(d) Explain the trend shown by these values in terms of the atomic structure of the elements.

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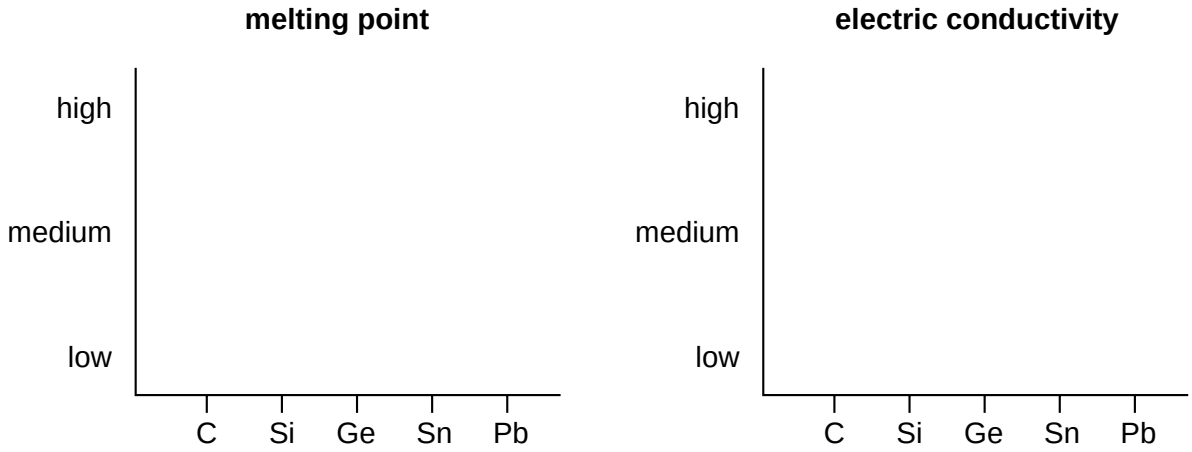
.....

..... [4]

[Total: 12]

4 **(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?

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

.....

.....

[3]

[Total: 13]

5 Compounds of phosphorus have many uses in everyday life, e.g. fertilisers, matches and in water softeners.

(a) State the full electronic configuration of phosphorus.

.....[1]

(b) Phosphoric acid, H_3PO_4, is used in the manufacture of phosphate fertilisers.

Deduce the oxidation number of phosphorus in H_3PO_4.

.....[1]

(c) The salt sodium phosphate, Na_3PO_4, is a water-softening agent.

(i) Write the equation for the complete neutralisation of phosphoric acid with aqueous sodium hydroxide.

.....

Sodium phosphate was prepared from 50.0 cm^3 of 0.500 mol dm^{-3} H_3PO_4 and an excess of aqueous sodium hydroxide.

(ii) How many moles of H_3PO_4 were used?

(iii) Use your equation in **(c)(i)** to calculate how many moles of sodium hydroxide are required.

[3]

(d) Phosphorus sulphide, P_4S_3, is used in small amounts in the tip of a match. On striking a match, this compound burns.

(i) Construct an equation for this reaction.

.....

(ii) Both oxides formed in **(i)** dissolve in water to give acidic solutions. Construct an equation for the reaction of each oxide with water.

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.....[4]

[Total : 9]