9. The Periodic Table: Chemical Periodicity

9.2 Periodicity of chemical properties

Paper 1

Question Paper

1 Which oxide is insoluble in aqueous sodium hydroxide?

A MgO **B** Al_2O_3 **C** P_4O_{10} **D** SO_2

2 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O_2	S + O_2
A	white flame	blue flame
B	white flame	yellow flame
C	yellow flame	blue flame
D	yellow flame	yellow flame

3 In this question Q is used to represent a halogen atom.

Magnesium and calcium each form a compound with chlorine and a compound with bromine.

One of these compounds contains:

- the element in Group 2 with the higher first ionisation energy **and**
- the element in Group 17 with the higher Q–Q bond energy.

What is the formula of this compound?

A $MgCl_2$ **B** $MgBr_2$ **C** $CaCl_2$ **D** $CaBr_2$

4 What are the acid–base nature and structure of SO_2?

	acid–base nature	structure
A	acidic	giant covalent lattice
B	acidic	simple molecular
C	basic	giant covalent lattice
D	basic	simple molecular

5 Elements X and Y are in Period 3 of the Periodic Table. Element X is either phosphorus or sulfur. Element Y is either sodium or magnesium.

Element X forms an oxide that reacts with water to give a solution containing the aqueous anion XO_4^{2-}.

One mole of element Y reacts with one mole of chlorine molecules. At the end of the reaction, all of the element Y and all of the chlorine molecules have been used up.

What are elements X and Y?

	X	Y
A	phosphorus	sodium
B	phosphorus	magnesium
C	sulfur	sodium
D	sulfur	magnesium

6 Q is a semi-conductor. The chloride of Q reacts with water to form white fumes and an acidic solution.

Which Period 3 element is Q?

A magnesium

B aluminium

C silicon

D phosphorus

7 Elements Y and Z are both in Period 3 of the Periodic Table.

When the chloride of element Y is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of element Z is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

A Both chlorides hydrolyse in water.

B Element Y is magnesium and element Z is sodium.

C Element Y is phosphorus and element Z is aluminium.

D Element Y is silicon and element Z is sodium.

8 Aluminium, silicon and phosphorus are elements in Period 3 of the Periodic Table. Each element forms an oxide.

Which row is correct?

	Al_2O_3	SiO_2	P_4O_{10}
A	basic	amphoteric	acidic
B	giant ionic	giant ionic	simple molecular
C	high melting point	high melting point	low melting point
D	vigorous reaction with water	slight reaction with water	vigorous reaction with water

9 Which statement is correct?

A Aluminium chloride has a giant ionic lattice of Al^{3+} and Cl^- ions.

B Sodium chloride dissolves in water, forming hydrogen chloride and sodium hydroxide.

C The strong covalent bonds in silicon chloride prevent it from reacting with water.

D When phosphorus(V) chloride is added to water, the resulting solution conducts electricity.

10 X, Y and Z are elements all found within Groups 13, 14 and 15 of the Periodic Table.

X is in the same group in the Periodic Table as Y.

Y and Z are in Period 3.

The first ionisation energy of X is greater than the first ionisation energy of Y.

The melting point of Z is less than the melting point of Y.

Y and Z both form chlorides which are white solids. These white solids react with water to produce solutions with a pH of less than 4.

Which row of the table shows the possible identities of X and Y?

	X	Y
A	B	Al
B	Ge	Si
C	As	P
D	N	P

11 Bromocresol green is an acid-base indicator. Below a pH of 3.8 it is yellow. Above a pH of 5.4 it is blue. Between these values it is green.

Bromocresol green is added to the aqueous solution formed when the chloride of element T is added to water. The colour becomes yellow.

When an excess of the solid oxide of element U is slowly added to this yellow solution, the indicator turns green then blue.

Which row could identify element T and element U?

	element T	element U
A	silicon	sodium
B	silicon	phosphorus
C	magnesium	sodium
D	magnesium	phosphorus

12 Four mixtures are added to four separate 50 cm^3 samples of water and stirred.

Which mixture results in a solution with the highest pH?

A 1.0 g of aluminium oxide and 1.0 g of aluminium chloride

B 1.0 g of magnesium oxide and 1.0 g of magnesium chloride

C 1.0 g of phosphorus oxide and 1.0 g of phosphorus chloride

D 1.0 g of silicon dioxide and 1.0 g of silicon chloride

13 SiO_2 has a melting point of 1713 °C. It reacts with hot NaOH(aq) to form sodium silicate, Na_2SiO_3, and water.

No reaction occurs when SiO_2 is added to hot H_2SO_4(aq).

What can be deduced from this information?

	chemical behaviour of SiO_2	structure of SiO_2
A	amphoteric	giant
B	amphoteric	simple
C	acidic	giant
D	acidic	simple

14 A solution contains both $Mg^{2+}(aq)$ and $Sr^{2+}(aq)$ at the same concentration.

The solution is divided into two equal portions. Aqueous sodium hydroxide is added dropwise to one portion. Dilute sulfuric acid is added dropwise to the other portion.

Which row is correct?

	precipitate seen first when NaOH(aq) is added	precipitate seen first when $H_2SO_4(aq)$ is added
A	magnesium hydroxide	magnesium sulfate
B	magnesium hydroxide	strontium sulfate
C	strontium hydroxide	magnesium sulfate
D	strontium hydroxide	strontium sulfate

15 In reactions 1 and 2, X represents an element in Period 3.

In each reaction, X is forming a product where X is in its highest oxidation state.

reaction 1 chlorine + element X $\rightarrow X_yCl_z$

reaction 2 oxygen + element X $\rightarrow X_pO_q$

Which ratios show a steady increase from sodium to phosphorus?

A neither z : y nor q : p

B z : y only

C q : p only

D both z : y and q : p

16 Sodium, magnesium, aluminium, silicon and phosphorus are all elements in Period 3 of the Periodic Table.

Three statements about the oxides and chlorides of these elements are given.

1 The ionically bonded oxides all react with dilute hydrochloric acid.

2 All metal chlorides produce neutral solutions when added to water.

3 The two most electronegative elements both form covalently bonded chlorides.

Which statements are correct?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

17 The electrical conductivities of two compounds, Y and Z, are shown.

	for Y	for Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What are compounds Y and Z?

	Y	Z
A	Al_2O_3	$SiCl_4$
B	$NaCl$	Al_2O_3
C	$NaCl$	$SiCl_4$
D	$SiCl_4$	Al_2O_3

18 Separate 1.0 g samples of Na_2O, MgO, Al_2O_3, SiO_2, $NaCl$, $MgCl_2$, Al_2Cl_6 and $SiCl_4$ are added to separate beakers containing water and stirred.

The number of beakers containing a white solid is Q.

An excess of NaOH(aq) is then added to each beaker and stirred.

The number of beakers now containing a white solid is R.

Which row is correct?

	Q	R
A	3	2
B	3	3
C	4	3
D	4	4

19 Element X requires strong heating to react with oxygen.

Element X reacts with chlorine to give a covalently-bonded chloride.

What could be the identity of element X?

A magnesium

B phosphorus

C sodium

D silicon

20 T is an element in Period 3.

The first ionisation energy of T is lower than that of the element with one less proton.

The oxide of T does not react with water.

What is the identity of T?

A aluminium

B silicon

C sodium

D sulfur

21 A student reacts 0.100 mol of each of sodium, magnesium and phosphorus atoms separately with an excess of oxygen.

Which rows are correct?

	oxide	mass of oxide formed / g
1	sodium	3.10
2	magnesium	4.03
3	phosphorus	7.10

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

22 Silicon is heated in an excess of chlorine, producing compound J.

An excess of water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HC*l* produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

23 Elements J and L are both in Group 15.

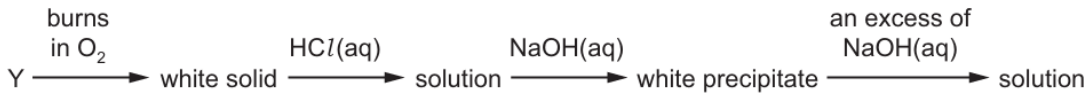
J and L each form a gaseous covalent hydride in which their oxidation number is –3.

In the liquefied forms of these hydrides, significant hydrogen bonding occurs only in the hydride of L.

Which row about J and L could be correct?

	identity of J	identity of L	outer shell electron configuration
A	As	N	p^5
B	As	N	s^2p^3
C	N	As	p^5
D	N	As	s^2p^3

24 An element, Y, reacts according to the following sequence.



What could be element Y?

A Na **B** Mg **C** Al **D** P

25 A mixture of two Period 3 oxides are added to water. A solution forms with a pH of just below 7.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

26 Element X is in Period 3. Element X forms a solid oxide Y.

Y reacts with hot concentrated hydrochloric acid. Y reacts with hot aqueous sodium hydroxide to form a compound in which X is part of an anion.

How many p electrons does one atom of X have in its outer shell?

A 0 **B** 1 **C** 2 **D** 3

27 R is an oxide of Period 3 element T. 5.00 g of R contains 2.50 g of T.

What is T?

A magnesium

B aluminium

C silicon

D sulfur

28 A sample of $SiCl_4$ is added to cold water.

Which statement describes the mixture formed at the end of the reaction?

A acidic solution with no precipitate

B acidic solution with white precipitate

C neutral solution with no precipitate

D neutral solution with white precipitate

29 X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

A AlP **B** Al_2S_3 **C** Si_2P_5 **D** SiS_2

30 Element X, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise $HCl(aq)$.

What is element X?

A Mg **B** Al **C** Si **D** P

31 Compound X is the oxide of a Period 3 element. Compound X reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of compound X with an excess of water. This solution is neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of compound X?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

32 Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which pair shows two elements which could be Z?

A aluminium, magnesium

B aluminium, silicon

C phosphorus, magnesium

D phosphorus, silicon

33 Sodium, aluminium and silicon are three elements in Period 3. Each element forms an oxide.

Which row has three correct properties of these oxides?

	sodium oxide	aluminium oxide	silicon dioxide
A	basic	basic	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	low melting point	high melting point
D	reacts with water	no reaction with water	no reaction with water

34 What is the order of increasing melting point of the three chlorides shown?

CCl_4 $MgCl_2$ PCl_5

	lowest melting point	→	highest melting point
A	CCl_4	PCl_5	$MgCl_2$
B	$MgCl_2$	CCl_4	PCl_5
C	$MgCl_2$	PCl_5	CCl_4
D	PCl_5	CCl_4	$MgCl_2$

35 One molecule of an oxide of element Z reacts with six molecules of water to produce an acidic compound.

What is element Z?

A aluminium

B phosphorus

C silicon

D sulfur

36 Which oxide will cause an increase in pH when added to water?

A MgO **B** Al_2O_3 **C** SiO_2 **D** SO_2

37 Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.

Where could element Q be found in the Periodic Table?

	period	group
A	2	1
B	2	14
C	3	14
D	3	15

38 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O_2	S + O_2
A	white	blue
B	white	yellow
C	yellow	blue
D	yellow	yellow

39 X and Y are elements in Period 3 of the Periodic Table.

- The oxide of X is a solid at room temperature. This oxide has a giant structure.
- The chloride of X does not react with water.
- Argon is the only element in Period 3 with a lower melting point than Y.

What could be the formula of a compound formed between elements X and Y?

A Al_2S_3 **B** MgS **C** $NaCl$ **D** PCl_5

40 Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

41 Silicon is heated in an excess of chlorine, producing compound J.

Excess water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

42 Which oxide does **not** react with cold, dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2