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Trial STPM 2023 Kimia Semester 1 SMK Tasek Utara, Johor Bahru

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Section A [*15 marks*]

*Answer **all** questions in this section.*

1 Skin cancer can be treated using a radioactive isotope of phosphorus, $^{32}_{15}P$. A compound containing the phosphide ion $^{32}_{15}P^{-3}$, wrapped in a plastic sheet, is strapped to the affected area.
What is the composition of the phosphide ion, $^{32}_{15}P^{-3}$?

	Protons	*Neutrons*	*Electrons*
A	15	17	18
B	15	17	32
C	17	15	17
D	32	17	15

2 Which statement about a 3*p* orbital is correct?

A It can hold a maximum of 6 electrons.

B It has the highest energy of the orbitals with principal quantum number $n = 3$.

C It is at a higher energy level than a 3s orbital but has the same shape.

D It is occupied by two electrons in an isolated sulphur atom.

3 Four electronic configurations are shown below. Three of these configurations belong to atoms of the elements chlorine, copper and magnesium.
Which electronic configuration belongs to an atom of another element?

A $1s^2 2s^2 2p^6 3s^2$

B $1s^2 2s^2 2p^6 3s^2 3p^2$

C $1s^2 2s^2 2p^6 3s^2 3p^5$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

4 Sodium hydrogensulphide, NaSH, is used to remove hair from animal hides.
Which statement is **not** true about SH^- ion?

A The formal charge is on the hydrogen atom.

B Three lone electron pairs surround the sulphur atom.

C The bond between sulphur and hydrogen is a single covalent bond.

D The total number of valence electrons is 8.

5 Which element shows the greatest tendency to form some covalent compounds?

A Sodium **B** Magnesium **C** Calcium **D** Aluminium

6 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

A Ethanol **B** Water

C Bromine **D** Hydrogen chloride

7 In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved. After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa. Which statement is true?

A Intermolecular forces between the gas molecules are significant.

B It is possible to calculate the number of moles of gas present using these data alone.

C The gas obeys the ideal gas law.

D The pressures used are too high for ideal gas behaviour.

8 Ethane-1,2-diol, $HOCH_2CH_2OH$, is used as antifreeze. It allows ice to melt at temperatures below 0 °C. Which statement best explains this property?

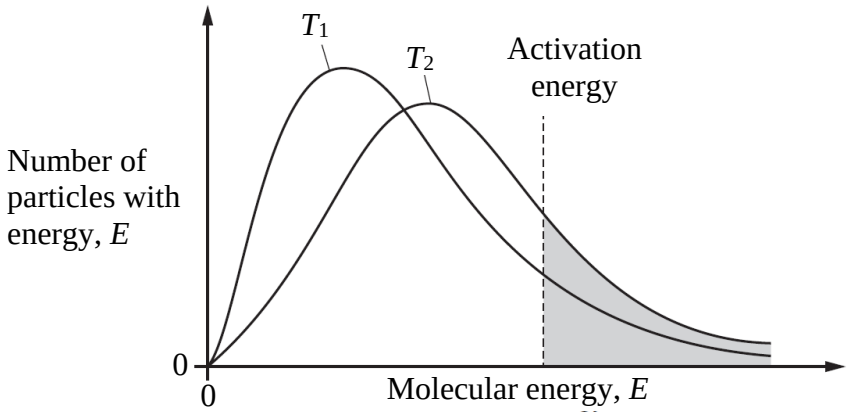
A Ethane-1,2-diol forms an insulating layer on the surface of water.

B Ethane-1,2-diol disrupts the extensive network of hydrogen bonds in ice.

C Ethane-1,2-diol molecules form hydrogen bonds with other ethane-1,2-diol molecules.

D Ethane-1,2-diol molecules will dissolve in the water formed from the ice.

9 The Boltzmann distribution diagram shows a fixed amount of a gas at two different temperatures, T_1 and T_2.



Which statements correctly describe the features of this diagram?

I Temperature T_1 is lower than temperature T_2.

II The shaded area indicates the particles that have sufficient energy to react at T_2.

III The total area under each curve is the same for both temperatures.

IV The peak of the curve will shift to the left when temperature increases.

A I and II **B** I and IV **C** II and III **D** III and IV

10 Crotonaldehyde, $CH_3CH=CHCHO$, can be obtained by oxidising butadiene, $CH_2=CHCH=CH_2$, using air or oxygen. One method is to pass a mixture of butadiene and oxygen through a hot aqueous solution of palladium(II) ions, $Pd^{2+}(aq)$, which catalyse the reaction.
Which statement is **not** correct about the action of the $Pd^{2+}(aq)$ ions?

A Changing the concentration of the $Pd^{2+}(aq)$ will have an effect on the rate of the reaction.

B $Pd^{2+}(aq)$ increases the energy of the reacting molecules.

C $Pd^{2+}(aq)$ lowers the activation energy for the reaction.

D When $Pd^{2+}(aq)$ is used, the reaction proceeds by a different route.

11 Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture. What is the value of K_c under these conditions?

A 3.96×10^{-3} **B** 5.29×10^{-3} **C** 7.39×10^{-3} **D** 1.15×10^{-2}

12 In the Contact process for the production of sulphuric acid, sulphur dioxide is mixed with air and passed over a vanadium(V) oxide catalyst at about 450°C and a pressure of 1.00 atm.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \; ; \; \Delta H \text{ negative}$$

What affects the choice of conditions for this reaction?

A A lower temperature would not raise the concentration of SO_3 at equilibrium.

B The use of vanadium(V) oxide catalyst increases the rate of oxidation of SO_2.

C Increasing the volume of the reaction vessel will increase the yield of SO_3.

D The K_c of the reaction is the same as the K_p at equilibrium.

13 In which reaction is the underlined substance acting as a base?

A $HNO_3 + \underline{H_2SO_4} \longrightarrow H_2NO_3^+ + HSO4^-$

B $HSiO_3^- + \underline{HCN} \longrightarrow CN^- + H_2O + SiO_2$

C $HNO_2 + \underline{HCO_3^-} \longrightarrow H_2O + CO_2 + NO_2^-$

D $C_6H_5O^- + \underline{CH_2ClCO_2H} \longrightarrow C_6H_5OH + CH_2ClCO_2^-$

14 Silver chloride, AgCl is partially soluble in water. In a saturated solution of AgCl, the concentration of silver ion, Ag^+ at 298 K is 1.33×10^{-5} mol dm^{-3}. Which of the following statement is true?

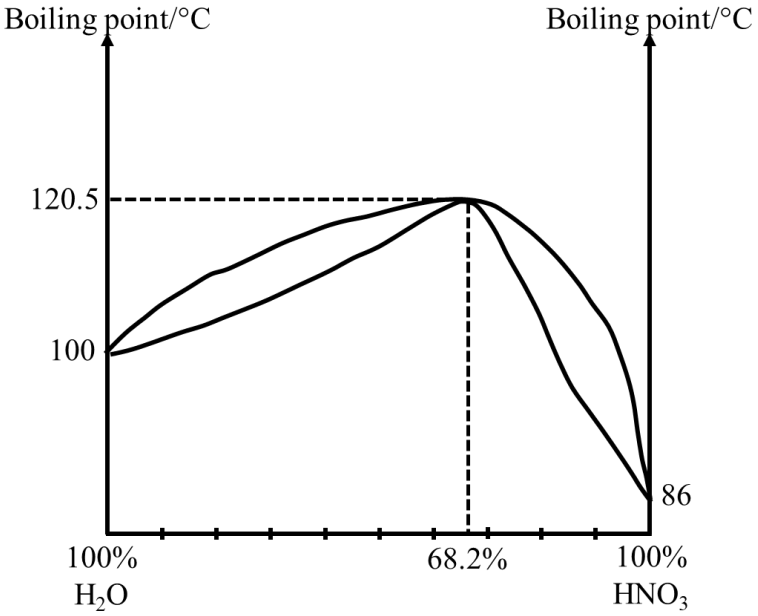
A The solubility of silver chloride is 1.33×10^{-10} mol dm^{-3}.

B Precipitate will form when the saturated solution is heated.

C The unit of the solubility product is $mol^3\ dm^{-9}$.

D Precipitate will form after adding HCl(aq) into saturated AgCl solution.

15 The following diagram shows the boiling point-composition curve for mixture of H_2O and HNO_3 at constant pressure.

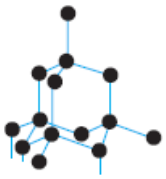
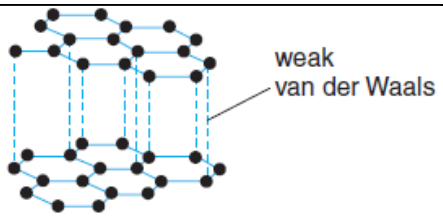
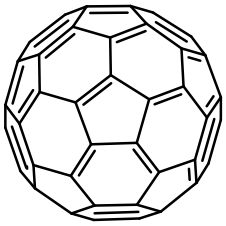


What is the composition of the two liquids obtained when a mixture of 30% H_2O is subjected to efficient fractional distillation?

	First distillate	*Second distillate*
A	H_2O	Azeotropic mixture
B	Azeotropic mixture	H_2O
C	HNO_3	Azeotropic mixture
D	H_2O	HNO_3

*This question paper is CONFIDENTIAL until examination is over.
(Kertas soalan ini SULIT sehingga peperiksaan kertas ini tamat.)

17. Table below shows the structure of allotropes for carbon

Allotrope of carbon	Diamond	Graphite	Fullerene
Diagram	 diamond	 graphite	

(a) Define allotropes [1]

……

……

(b) Complete the table below by filling in the blanks with the hybridisation of carbon atoms, and electrical conductivity for each allotropes involved [2]

Allotrope of carbon	Diamond	Graphite	Fullerene
(i) Hybridisation			
(ii) Electrical conductivity			

(c) Based on table filled in (b), explain the conductivity between graphite and fullerene based on the structure involved [2]

……

……

……

……

(d) State an application for each allotropes of carbon [3]

(i) Diamond : ……

(ii) Graphite : ……

(iii) Fullerene : ……

Section C [30 marks]

Answer TWO of these questions below in the examination pad

18. (a) Because of differing proportions of isotopes, the relative mass of lead depends on its source. Two samples of lead were subjected to analysis.

(i) Lead sample A : The mass spectrum of the first sample was taken and the following results were obtained

m/e value	204.0	206.0	207.0	208.0
relative abundance	27.0	48.0	41.5	100.0

Calculate the relative atomic mass of lead from the analysis of mass spectra [2]

(ii) Lead sample B : When 1.000 g of the second sample of lead was burned with excess chlorine, a total of 1.341 g of lead (II) chloride. Assume that the yield formed is 100%, calculate the relative atomic mass of second sample of lead. [5]

(iii) From both lead sample A and sample B, determine if both of them were from the same abundance. Explain your answer [2]

(b) Lead, lead(II) chloride and lead(IV) chloride have different melting points, as describe in the table below.

Substances	Lead, Pb	Lead(II) chloride, $PbCl_2$	Lead(IV) chloride, $PbCl_4$
Melting point / °C	327.5	501.0	-15.0

Based on the structure and bonding, explain the difference of melting between lead and its compounds [6]

19. (a) Carbon atom uses hybrid orbitals to form organic compound such as propyne, $CH_3C{\equiv}CH$. Using energy level diagram and hybrid orbitals diagram, describe the hybridisation involved and state the shapes and angle for each carbon involved. [7]

(b) Both ethyne and nitrogen molecules contain triple bonds. The reactivity of ethyne is greater than that of nitrogen. Explain this difference in reactivity. [2]

(c) Nitrogen oxide can formed as nitrogen dioxide, NO_2 and nitrate ion, NO_3^-. By drawing the Lewis diagram for both NO_2 and NO_3^-, state the shape and angle for both molecules involved [6]

<table>
<tr><td>1</td><td>A</td><td>$^{32}_{15}P^{-3}$
Number of protons = 15, Number of neutrons = 32 – 15 = 17, Number of electrons = 15 + 3 = 18</td></tr>
<tr><td>2</td><td>A</td><td>It can hold a maximum of 6 electrons. (True)
It has the highest energy of the orbitals with principal quantum number $n = 3$. (False, 3d has the highest energy)
It is at a higher energy level than a 3s orbital but has the same shape. (False, different shape)
It is occupied by two electrons in an isolated sulphur atom. (False, 4 electrons).</td></tr>
<tr><td>3</td><td>B</td><td>$1s^2 2s^2 2p^6 3s^2$: magnesium
$1s^2 2s^2 2p^6 3s^2 3p^2$: silicon
$1s^2 2s^2 2p^6 3s^2 3p^5$: chlorine
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$: copper</td></tr>
<tr><td>4</td><td>A</td><td>The formal charge is on the hydrogen atom. (False, on sulphur atom)</td></tr>
<tr><td>5</td><td>D</td><td>Aluminium has the highest charge density.</td></tr>
<tr><td>6</td><td>C</td><td>Ethanol and water has hydrogen bonds, hydrogen chloride has permanent dipole, bromine has only temporary dipole.</td></tr>
<tr><td>7</td><td>C</td><td>Let T_1 = 300 K, $P_1 = 16$ kPa, T_2 = 375 K, $P_1 = 40$ kPa.
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{(16)V_1}{(300)} = \frac{(40)V_2}{(375)} \Rightarrow V_1 = 2V_2$ (Obeys ideal gas law)
Intermolecular forces between the gas molecules are significant. (False, since obeys ideal gas law)
It is possible to calculate the number of moles of gas present using these data alone. (False, insufficient)
The pressures used are too high for ideal gas behaviour. (False, since obeys ideal gas law)</td></tr>
<tr><td>8</td><td>B</td><td>Ethane-1,2-diol disrupts the extensive network of hydrogen bonds in ice. (Best explains the lowering of melting point).</td></tr>
<tr><td>9</td><td>C</td><td>Temperature T_1 is higher than temperature T_2. (False)
The shaded area indicates the particles that have sufficient energy to react at T_2. (True)
The total area under each curve is the same for both temperatures. (True)
The peak of the curve will shift to the left when temperature increases. (False)</td></tr>
<tr><td>10</td><td>B</td><td>Changing the concentration of the Pd^{2+}(aq) will have an effect on the rate of the reaction. (True).
Pd^{2+}(aq) increases the energy of the reacting molecules. (False)
Pd^{2+}(aq) lowers the activation energy for the reaction. (True)
When Pd^{2+}(aq) is used, the reaction proceeds by a different route. (True)</td></tr>
<tr><td>11</td><td>A</td><td>
<table>
<tr><td></td><td>N_2</td><td>H_2</td><td>NH_3</td></tr>
<tr><td>Initial</td><td>2.00</td><td>6.00</td><td>2.40</td></tr>
<tr><td>At equilibrium</td><td>2.32</td><td>6.96</td><td>1.76</td></tr>
<tr><td>Change</td><td>+0.32</td><td>+0.96</td><td>−0.64</td></tr>
</table>
$K_c = \frac{(1.76)^2}{(2.32)(6.96)^3} = 3.96 \times 10^{-3}\ \text{mol}^{-2}\ \text{dm}^6$
</td></tr>
<tr><td>12</td><td>B</td><td>A lower temperature would not raise the concentration of SO_3 at equilibrium. (False)
The use of vanadium(V) oxide catalyst increases the rate of oxidation of SO_2. (True)
Increasing the volume of the reaction vessel will increase the yield of SO_3. (False)
The K_c of the reaction is the same as the K_p at equilibrium. (False)</td></tr>
<tr><td>13</td><td>C</td><td>HCO_3^- first accepts H^+ to form H_2CO_3, then decomposes into H_2O and CO_2.</td></tr>
<tr><td>14</td><td>D</td><td>The solubility of silver chloride is 1.33×10^{-10} mol dm^{-3}. (False, it's 1.33×10^{-5} mol dm^{-3}
Precipitate will form when the saturated solution is heated. (False, it will dissolve)
The unit of the solubility product is mol^3 dm^{-9}. (False, it is mol^2 dm^{-6}
Precipitate will form after adding HCl(aq) into saturated AgCl solution. (True, common ion effect)</td></tr>
<tr><td>15</td><td>C</td><td>30% H_2O will yield pure HNO_3 as first distillate and azeotropic mixture as second distillate.</td></tr>
</table>

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