USEFUL INFORMATION: 1 atm = 101.3kPa = 760mmHg; R = 8.314J $mol^{-1}K^{-1}$ = 0.0821dm^3atm $mol^{-1}K^{-1}$; the molar volume of any gas at STP is 22.4 dm^3 mol^{-1}; Avogadro's number = 6.0×10^{23}

SECTION I: MULTIPLE CHOICE

Select the SINGLE best alternative in each of the following cases and '***SHADE IN***' in the appropriate letter on the separate multiple choice answer sheet. (30 MARKS)

1) How many molecules are in 100 cm^3 of $SO_3(g)$ at 100°C and 1.00 atm?
A 3.27×10^{20}
B 1.97×10^{21}
C 1.97×10^{-21}
D 5.12×10^{22}
E 6.02×10^{23}

2) In which of the following pairs of aqueous solutions will a precipitate NOT form.
A barium chloride and copper(II) nitrate
B silver nitrate and sodium chloride
C potassium carbonate and barium nitrate
D zinc chloride and sodium hydroxide
E iron(III) sulphate and ammonia

3) Which one of the following ions is *NOT* isoelectronic with the neon atom?
A Na^+
B O^{2-}
C Al^{3+}
D Ca^{2+}
E F^-

4) Sulphur tetrafluoride, SF_4 is an example of a
A T-shaped molecule
B tetrahedral molecule
C bent molecule
D distorted tetrahedral (seesaw)
E trigonal pyramidal

5) In a mixture of CO(g) and $CO_2(g)$, the mole fraction of CO(g) (X_{CO}) is 0.22. If the pressure of the mixture is 3.00 atm, the partial pressure of CO_2 is
A 0.66 atm
B 1.25 atm
C 2.21 atm
D 2.34 atm
E impossible to determine

6) The root-mean-square speed of an ideal gas can defined by the following expression,

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

where T is the temperature of the gas. If the temperature of a gas is doubled, how much is the root-mean-square speed (μ_{rms}) of the molecules increased?
A by a factor of $2_{1/2}$
B by a factor of $2^{1/2}$
C by a factor of $3/2$
D by a factor of $3^{1/3}$
E by a factor of 6

7) Which of the following salts is NOT soluble in water
A K_2CO_3
B Na_2SO_4
C $BaCO_3$
D K_2CrO_4
E $AgNO_3$

8) 30 cm^3 of water is added to 50 cm^3 of a solution with molarity M at a constant temperature. After dilution the molarity of the solution is
A 3/5 M
B 3/8 M
C 5/8 M
D 8/5 M
E M

9) A 0.2 mol sample of a hydrocarbon C_xH_y yields, after complete combustion with excess O_2 gas, 0.80 mol of CO_2 and 0.4 mol of H_2O as the only products. The molecular formula of the hydrocarbon is
A C_2H_2
B C_2H_4
C C_2H_6
D C_4H_8
E C_4H_{10}

8) When dilute hydrochloric acid is added to a solution containing $Ag^+(aq)$ a white precipitate forms. This precipitate dissolves when a dilute ammonia solution is added. In what form is the silver in the final solution?
A Ag(s)
B AgCl(s)
C $Ag(OH)_4^{3-}(aq)$
D $Ag(OH)_2^-(aq)$
E $Ag(NH_3)_2^+(aq)$

11) What is the total number of ions present in 1.42g of Na_2SO_4 (RFM = 142)?
A 0.01
B 0.03
C 6.0×10^{21}
D 1.2×10^{22}
E 1.8×10^{22}

12) Arrange the following atoms in order of DECREASING electronegativity.
A As, F, S, Y, Zn
B F, S, As, Zn, Y
C F, Y, Zn, As, S
D F, Zn, Y, S, As
E F, S, As, Y, Zn

13) A nonpolar molecule is defined as
A a molecule with a dipole moment
B an ionic compound
C a molecule with no net dipole
D a molecule with only bond pair/lone pair replusion
E a molecule with equal bond angles

14) Two glass bulbs are connected by a closed centre valve. A 500 cm^3 bulb is filled with $N_2(g)$ at 25°C to a pressure of 3.0 atm and a 1.00 dm^3 bulb is filled with $O_2(g)$ at 25°C to a pressure of 6.0 atm. If the centre valve is opened allowing the gases to mix and no temperature change is observed, the final pressure in the apparatus will be
A 3.0 atm
B 4.0 atm
C 5.0 atm
D 6.0 atm
E 7.0 atm

15) An aqueous sodium hydroxide solution is 30.0% by mass and has a density of 1.33 gcm^{-3} What is the molarity of the solution?
A 9.98 M
B 33.3 M
C 15.96 M
D .0998 M
E 19.96 M

QUESTIONS 16-22 concern the following elements:

A C
B Cl
C Zn
D K
E S

16) This element has the lowest ionization energy.
17) This element's ion is isoelectronic with Argon.
18) This element has a high electronegativity.
19) This element is one of the d-block elements.
20) This element forms a linear molecule with oxygen.
21) This element forms a white precipitate with hydroxide ions.
22) This element gives a lilac coloured flame in a flame test.

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23) The following elements are in the fourth period of the periodic table.
Ca V Co Zn As
Of those listed, which ones all have unpaired electrons in the ground state?
A Ca, V and Co
B V, Co and Zn
C Ca, Zn and As
D V, Co and As
E Zn and As

24) When 1105 J of heat is added to 36.5g of ethyl alcohol, C_2H_5OH, the temperature increases by 12.3°C. What is the molar heat capacity of ethyl alcohol in $JK^{-1}mol^{-1}$ (RMM=46)?
A 4.88
B 113
C 8.97
D 0.204
E 2.55

25) The first seven ionization energies of an element X are 1010, 1900, 2900, 5000, 6300, 21 300 and 25 400 kJ mol^{-1}. In which group of the Periodic Table is X?
A 1
B 2
C 3
D 4
E 5

26) Which one of the following sets of elements has atomic radii which change only slightly with increasing atomic number?
A the noble gases
B the halogens
C the transition elements
D the alkali metals
E the alkaline earth metals

27) When excess zinc reacts with 0.5 mol of copper(II) ions in solution, 108 kJ of energy is released. What is the heat of reaction, $\Delta H°$?
A -108 kJ
B +108 kJ
C -216 kJ
D -162 kJ
E +216 kJ

28) For which of the following substances does $\Delta H_f° = 0$
A $Br_2(g)$
B N(g)
C C(g)
D CO(g)
E Ne(g)

29) A porous container is filled with equal amounts of $N_2(g)$ and an unknown gas. The $N_2(g)$ escaped 2.3 times faster than the unknown gas through a tiny hole. What is the molar mass of the unknown gas?
A 148
B 146
C 64
D 32
E 12

30) If a sample of an ideal gas, in a sealed container of fixed volume, is heated from 10 to 40°C, which of the following quantities will remain constant?
A The pressure of the gas
B The total kinetic energy of the gas
C The average speed of the molecules
D The density of the gas
E The temperature of the gas

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SECTION II: STRUCTURED QUESTIONS

Answer each of the following questions in the spaces provided on the question paper. Clear and concise expression is an essential part of a good answer.

1) A closed glass bulb contains 0.010 mol of inert helium gas and a sample of solid ammonium chloride, NH_4Cl. Assume that the volume of the solid NH_4Cl is negligible compared to the volume of the bulb. The pressure of the He is measured at 27°C and is found to be 114 mmHg. The bulb is then heated to 327°C. All the NH_4Cl decomposes according to the equation

$$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$$

The final total pressure in the bulb after complete decomposition of the solid is 908 mmHg. Assume all gases are ideal.

a) Calculate the pressure (in mmHg) of the He at 327°C. (4 MARKS)

b) What is the partial pressure (in mmHg) of the HCl(g) at 327°C when the reaction is complete? Note from the equation above that the partial pressure of HCl(g) and $NH_3(g)$ are must be equal after reaction is complete. (4 MARKS)

c) Since the V and T are the same for all gases after reaction, the partial pressure (P) of the gas is directly proportional to the moles (n) of gas. Use this fact to calculate the number of moles of HCl(g) in the mixture after reaction. (4 MARKS)

2) Calculate the standard enthalpy of formation of $Ca(OH)_2(s)$ from the following data. (6 MARKS)

(1) $2H_2(g) + \frac{1}{2}O_2(g) \rightarrow 2H_2O(l)$ $\Delta H_1 = -571.66$ kJ mol^{-1}

(2) $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ $\Delta H_2 = -65.17$ kJ mol^{-1}

(3) $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ $\Delta H_3 = -1270.2$ kJ mol^{-1}

3) Draw Lewis structures for each of the following molecules and state the shape of each molecule according to VSEPR theory. Show ALL valence electrons in your diagrams. (9 MARKS)

MOLECULE OR ION	LEWIS STRUCTURE	*SHAPE*
i) SCl_2		
ii) $COCl_2$		
iii) ICl_4^-		

4) (a) How many valence electron are there in (3 MARKS)

(i) Al^{3+}

(ii) Mg^{2+}

(iii) Cl^-

(b) (i) Predict the ground state electron configuration of an arsenic atom (Z=33). (1 MARK)

(ii) Draw the orbital diagram for O^+. (2 MARKS)

For example, the orbital diagram for lithium is $\frac{1\downarrow}{1s}\ |\ \frac{1}{2s}$.

(c) Which of the following sets of four quantum numbers are not allowed for an electron in an atom? Explain your choice. (2 MARKS)

(4, 2, 2, +1/2) (4, 1, 0, -1/2) (4, 2, 3, +1/2)

Briefly explain why is there no 3f orbital? (2 MARKS)

The following question is concerned with qualitative analysis test performed in the lab. Write net ionic equations where appropriate to support your answers.

5) (a) How could you distinguish $BaSO_{4(s)}$ from $AgCl_{(s)}$? (2 MARK)

(b) What colour do the following ions impart to a flame? (3 MARKS)

Ba^{2+} _____

Na^{+} _____

Ca^{2+} _____

(c) What reagent will precipitate

(i) Ag^{+} but not Ca^{2+}? (1 MARK)

_____

_____

(ii) Ba^{2+} but not NH_4^{+}? (1 MARK)

_____

_____

(d) (i) How could you test for CO_3^{2-} in the presence of SO_3^{2-}? (2 MARKS)

_____

_____

(ii) How could you test for NO_3^{-} in the presence of I^{-}? (2 MARKS)

_____

_____

6) Arrange the following substances in order of INCREASING boiling points. Explain the reasons for the order you choose. (6 MARKS)

F_2 NaF HCl N_2 Ne H_2O

ORDER: _____

EXPLANATION:

_____

_____

_____

_____

_____

_____

END OF EXAMINATION