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=6.02 x 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. (25 MARKS)

1) How many molecules are in 22,400 cm^3 of $SO_3(g)$ at STP?
A 1
B 22,400
C 0.01 x 6.02 x 10^{23}
D 6.02 x 10^{23}
E 4 x 6.02 x 10^{23}

2) What is the total number of moles of ions present in 2 moles of $(NH_4)_2CO_3$?
A 2
B 6
C 14
D 28
E 28 x 6.02 x 10^{23}

3) 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

4) 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^-

5) 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

6) 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

7) 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

8) 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 $AgNO_3$

9) 1 cm^3 of water is added to 2 cm^3 of a solution with molarity M at a constant temperature. After dilution the molarity of the solution is
A 1/2 M
B 1/3 M
C 2/3 M
D 3 M
E M

10) A 0.2 mol sample of a hydrocarbon C_xH_y yields, after complete combustion with excess O_2 gas, 0.40 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}

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

12) Two glass bulbs are connected by a closed centre valve. A 0.50 dm^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

QUESTIONS 13-19 concern the following VSEPR shapes:

A bent or V-shaped
B trigonal planar
C tetrahedral
D trigonal pyramidal
E linear

13) O_3
14) CO_3^{2-}
15) SO_3
16) SO_3^{2-}
17) $SiCl_4$
18) CO_2
19) SO_2

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20) 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

21) 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

22) 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, $\Delta H°$ in $kJmol^{-1}$?
A -108
B +108
C -216
D -162
E +216

23) 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)

24) 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

25) If a sample of an ideal gas, in a sealed container of fixed volume, is heated from 10°C 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. (55 MARKS)

1) Excess aqueous hydrochloric acid was added to a 0.415 g sample of an alloy of aluminum and copper. The aluminium dissolved according to the reaction

$$Al(s) + 3HCl(aq) \rightarrow AlCl_3(aq) + 3/2H_2(g)$$

The copper did not dissolve and remained unchanged as the pure metal. The gaseous hydrogen produced was collected over water. The volume of the collected gas was 436 cm^3 at 24.6°C and 746.6 mmHg.

a) Write the net ionic equation for this reaction. (1 MARK)

b) If the alloy is 73.7% aluminium, calculate the vapour pressure of water at 24.6°C in mmHg? (5 MARKS)

2) a) In each of the following cases write a thermochemical equation to represent the statement given.

(i) The standard enthalpy of formation of water vapour is -241.8 $kJmol^{-1}$. (1 MARK)

(ii) The enthalpy of atomization of methane is 121 $kJmol^{-1}$. (1 MARK)

(iii) The second electron affinity of oxygen is 791 $kJmol^{-1}$. (1 MARK)

(iv) The enthalpy of combustion of propane (C_3H_8) is -2040 $kJmol^{-1}$. (1 MARK)

b) An element X has successive ionization energies in $kJmol^{-1}$

740, 1500, 7700, 10500, 13600, 18000, 21700

Another element Y has successive ionization energies in $kJmol^{-1}$

1310, 3400, 5300, 7500, 11000, 13300, 71300, 84100

(i) To which group of the periodic table does X belong? (1 MARK)

(ii) To which group of the periodic table does Y belong? (1 MARK)

(iii) What is the likely formula of the compound formed between X and Y? (1 MARK)

:) Use the bond energies given to predict a value for the standard enthalpy change for the reaction. (4 MARKS)

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

Bond energies:

C-C	345 $kJmol^{-1}$
C=C	610 $kJmol^{-1}$
Cl-Cl	239 $kJmol^{-1}$
C-Cl	335 $kJmol^{-1}$

3) The combustion of cyanamide, $N{\equiv}CNH_2$ (s) produces CO_2(g), N_2(g) and H_2O(l). The standard heat of combustion of cyanamide is -741 $kJmol^{-1}$. $\Delta H_f°(CO_2(g)=-393.5$ kJ $mol^{-1})$ and $\Delta H_f°(H_2O(l)=-285.8$ kJ $mol^{-1})$.

a) Write a balanced equation for the combustion of cyanamide. (2 MARKS)

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b) Calculate $\Delta H_f°(N{\equiv}CNH_2,s)$ (4 MARKS)

c) What mass of cyanamide must be burned to produce 100,000 J of heat? (2 MARKS)

4) a) The PF_3Cl_2 molecule has a dipole moment of zero. Use this information along with VSEPR theory to sketch its three dimensional shape. Explain your reasoning. (4 MARKS)

b) Which type of intermolecular forces of attraction exist between PF_3Cl_2 molecules? Explain your choice(s). (2 MARKS)

c) Do you think a similar compound, $PBrF_2Cl_2$, would have a higher or lower boiling point than PF_3Cl_2 ? Explain your reasoning. (3 MARKS)

5) Iodine, $I_2(aq)$, reacts with the thiosulfate ion, $S_2O_3^{2-}(aq)$ to form the iodide ion, $I^-(aq)$ and the tetrathionate ion, $S_4O_6^{2-}(aq)$.

a) Write the balanced chemical equation for this reaction. (1 MARK)

b) How many grams of I_2 will react with 25.0 cm^3 of a 0.050M solution of sodium thiosulphate, $Na_2S_2O_3$? (4 MARKS)

c) How many cm^3 of 0.050M $Na_2S_2O_3$ contains 690 mg of $Na^+(aq)$?(3 MARKS)

6) (a) How many valence electrons are there in (3 MARKS)

(i) Rb

(ii) Mg^{2+}

(iii) S^{2-}

(b) (i) Predict the ground state electron configuration of a selenium atom (Z=34). (1 MARK)

(ii) Draw the orbital diagram for V and Cu^+. (4 MARKS)

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

V:

Cu^+:

c) Which of the following sets of four quantum numbers, n, l, m_l, m_s 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)

d) The $\Delta H_f°$ for F(g) is 78.99 kJ mol^{-1} and the $\Delta H_f°$ for F^- (g) is - 255.39 kJ mol^{-1}. Calculate the first electron affinity for fluorine under these standard conditions. (3 MARKS)

END OF EXAMINATION