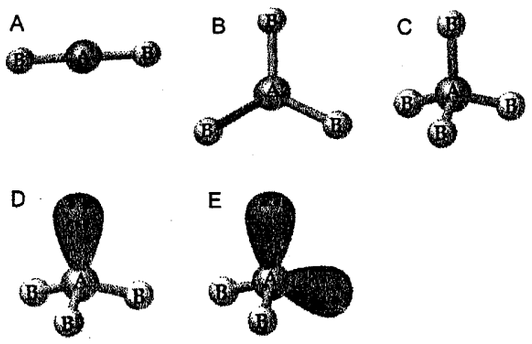
SOME USEFUL INFORMATION

1 atm = 101 000 Pa = 760 mmHg
The molar volume of any gas at s.t.p. is $22{\cdot}4\,dm^3mol^{-1}$
$R = 8{\cdot}31\,Jmol^{-1}K^{-1} = 0{\cdot}0821\,Latmmol^{-1}K^{-1}$
Avogadro's number = $6{\cdot}02 \times 10^{23}$

SECTION I: Multiple Choice Questions

Select the SINGLE best alternative in each of the following cases and indicate your answer by marking the corresponding letter on the answer sheet provided.

Questions 1-6 refer to the following diagrams:



Which diagram applies best to each of these molecules?

1) SO_3
2) CO_2
3) H_2O
4) CCl_4
5) BF_3
6) NCl_3

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Questions 7-11 refer to the ground state electronic configurations of five elements A to E.

A $1s^22s^22p^63s^23p^5$
B $1s^22s^22p^63s^23p^64s^1$
C $1s^22s^22p^63s^23p^63d^14s^2$
D $1s^22s^22p^63s^23p^63d^{10}4s^24p^2$
E $1s^22s^22p^63s^23p^63d^{10}4s^24p^6$

Select from A to E the element which
7) is a noble gas
8) forms an ion of charge -1
9) is a transition metal
10) forms a chloride having the formula XCl_4
11) is an alkali metal

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12) Which of the following halogens has the highest electronegativity
A fluorine
B chlorine
C bromine
D iodine
E astatine

13) Which of the following is **NOT** isoelectronic with the others?
A CH_4
B HF
C NH_4^+
D H_3O^+
E H_2S

14) Which of the following atoms in its ground state contains three unpaired electrons?
A lithium
B beryllium
C boron
D carbon
E nitrogen

15) Which molecule has zero dipole moment?
A H-F
B H-Cl
C F-Cl
D F-F
E Cl-Br

16) Which property does **NOT** vary periodically with atomic number?
A atomic mass
B first ionization energy
C electron affinity
D electronegativity
E atomic radius

17) Which group of elements occurs at the bottom of the troughs in a graph of first ionization energy against atomic number?
A group 8
B group 5
C group 3
D group 2
E group 1

18) What volume of 0.25M Na_2SO_4 contains the same number of moles as 100cm³ of 0.75M Na_2SO_4?
A 4cm³
B 33 cm³
C 300cm³
D 400 cm³
E 250cm³

19) 300cm³ of a 2.00M solution of KNO_3 is mixed with 200 cm³ of a 3.00M solution of KNO_3. The concentration of the resulting solution is
A 2.00M
B 2.40M
C 2.50M
D 3.00M
E 5.00M

20) The enthalpy of combustion of hydrogen is -218kJmol^{-1}. The enthalpy of formation of water, in kJmol^{-1}, is:
A -436
B +436
C -218
D +218
E +109

21) The total number of valence electrons in the phosphonium ion, PH_4^+
A 8
B 9
C 19
D 18
E 4

22) A certain volume of oxygen gas (molar mass 32gmol^{-1}) weighs 2.00g at a certain temperature and pressure. An equal volume of another gas, X, weighs 1.75g at the same temperature and pressure. The relative molecular mass of X is closest to:
A 112
B 64.0
C 56.0
D 36.5
E 28.0

23) X and Y are two gases which behave ideally. They do not react with each other. The mass of 1dm³ of X is twice that of 1dm³ of Y at room temperature and pressure. Which of the following is true for the gases under these conditions?
A The number of molecules in 1dm³ of X is twice the number of molecules in 1dm³ of Y.
B The average kinetic energy of a molecule of X is equal to the average kinetic energy of a molecule of Y.
C On mixing equal volumes of the gases, the partial pressure of X is twice that of Y.
D The molar mass of Y is twice that of X.
E The volume occupied by 1 mole of X is half of that occupied by 1 mole of Y.

24) Ammonia (NH_3) and boron trifluoride (BF_3) react on contact to form the molecule F_3B-NH_3. The bond between the boron atom and the nitrogen atom is best described as:
A a hydrogen bond
B an ionic bond
C a dative covalent bond
D a covalent bond
E a non-metallic bond

25) For which one of the following is the standard enthalpy of formation zero?
A $H_2O(l)$
B $H_2O(g)$
C Na(g)
D $H_2(g)$
E $H_2(s)$

26) 5.0g of an ionic compound $X^{2+}(Y^-)_2$ (RFM = 100) are dissolved in water and made up to 1.00dm³. What is the concentration of the solution with respect to Y^- ions?
A 0.050moldm^{-3}
B 0.10moldm^{-3}
C 0.15moldm^{-3}
D 0.20moldm^{-3}
E 0.40moldm^{-3}

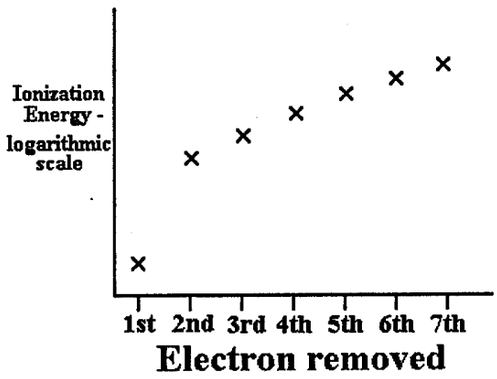
27) What intermolecular forces are possible between hydrogen fluoride molecules?
A Dipole/dipole interactions
B Hydrogen bonding
C London dispersion forces
D A and B but not C
E A, B and C

28) The volume of SO_2 measured at s.t.p. when 0.50mol of carbon disulfide is burned in excess oxygen according to the equation:
$CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$
is:
A 1dm³
B 5.6dm³
C 11.2dm³
D 22.4dm³
E impossible to determine

29) $15cm^3$ of a gaseous hydrocarbon, whose formula may be represented as C_xH_y, produced $45cm^3$ of carbon dioxide as measured under the same conditions of temperature and pressure as the hydrocarbon. The value of x is:

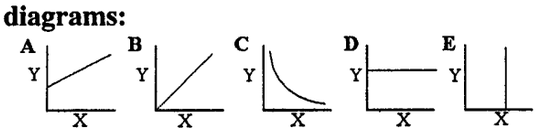
A 1
B 2
C 3
D 4
E impossible to determine

30) The graph below could refer to which of the following atoms?



A hydrogen
B lithium
C sodium
D A, B or C
E None of the above.

Questions 31 to 36 refer to the following diagrams:



Pick out the appropriate graph in each of the following cases.

31) Y is the rate of effusion of gases and X is the square root of their molar masses under given conditions of temperature and pressure.
32) Y is the density of gases and and X is their molar masses under the same condition of temperature and pressure.
33) Y is the velocity of the molecules of a gas and X is its pressure at constant temperature and volume.
34) Y is the pressure of a gas at constant volume and X is the temperature in °C when the number of moles and temperature are constant.
35) Y is the gas constant (R) and X is the pressure for a constant volume of an ideal gas at constant temperature.

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Questions 36 to 40 refer to the following orbitals or sets of orbitals:

A 3s
B 4f
C 3d
D 2p
E 5p

Select the appropriate orbital or set of orbitals in each case given the following information:

36) $l = 0$
37) $n = 2, l = 1$
38) m_l has five possible values.
39) This set can hold a total of 10 electrons in the third shell.
40) $m_l = 0$ only.

SECTION II: Structured Questions

Answer each of the following questions in the spaces provided on the question paper.

1) a) Calculate the number of moles present in $150cm^3$ of nitrogen at a temperature of 32°C and a pressure of 450mmHg. (4)

b) i) State Dalton's law of Partial Pressures. (1)

ii) A flask of volume 400m^3 contains a gas, A, at 80.0mmHg. A second flask, B, of volume 800cm^3 contains gas B at 170 mmHg and the same temperature as A. The two flasks are connected. Find the total pressure in the system when it has reached a steady state. (4)

c) All real gases deviate in their behaviour from that of an ideal gas. What two factors cause this deviation, and under what conditions do these deviations become important? (4)

d) On the axes given, show the distribution of kinetic energy in a sample of gas at temperatures T_1 and T_2 where $T_2 >> T_1$. Label the axes. (3)

2) a) Write a thermochemical equation corresponding to each of the following statements:

i) The first ionization energy of magnesium is $740 kJ mol^{-1}$. (3)

ii) The standard enthalpy of combustion of methane, CH_4, is $-890.4 kJ mol^{-1}$. (3)

iii) The standard enthalpy of formation of carbon dioxide is $-28 kJ mol^{-1}$. (3)

b) Given the standard enthalpies of formation of propane (C_3H_8), carbon dioxide (CO_2), and water (H_2O) are $-104 kJ mol^{-1}$, $-393 kJ\ mol^{-1}$, and $-286 kJ mol^{-1}$ respectively, find the standard enthalpy of combustion of propane. (3)

c) Explain why the second ionization energy of an element is always higher than the first. (2)

d) $100 cm^3$ of 1.0M hydrochloric acid are added to $100 cm^3$ of 1.0M sodium hydroxide solution in a calorimeter of negligible heat capacity. A temperature rise of 6.9°C is measured. Calculate the molar enthalpy of neutralisation of hydrogen ions in $kJ mol^{-1}$, given that the specific heat capacity of the solution is $4.2 J g^{-1} K^{-1}$. (4)

3) The following question concerns solutions and titrations.

a) i) What is meant by "making up to the mark" in a volumetric flask? (2)

ii) What is meant by the term "concordant titres"? (1)

iii) What is meant by the term "deliquescent"? Give one example of a deliquescent substance and explain why a solution of known molarity cannot be made from it by weighing it out dissolving in a known volume of water. (3)

b) What is the molarity of a solution of H_2SO_4 if 42.7cm^3 of it is required to exactly titrate 27.5cm^3 of 0.612M NaOH solution? The equation for the reaction is;

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$ (4)

SECTION III: Essay Questions

Answer **ONE** of the following questions on the lined paper provided. Each question is worth 12 marks.

1) Give explanations for each of the following statements: (3 marks each part)
   a) CH_2 (a short-lived molecule) is V-shaped whilst CS_2 is linear.
   b) Water has a higher boiling point than hydrogen sulphide even though water has a lower molar mass.
   c) Metals are good conductors of electricity when solid, whereas ionic substances can only conduct electricity when molten or in solution.
   d) All the bond lengths in the nitrate ion are equal.

2) When 1.000g of a compound, known to contain only carbon, hydrogen, and oxygen, is burned in air, 1.910g of carbon dioxide and 1.173g of water are formed. The vapour of the compound is 1.65 times as dense as nitrogen under the same conditions of temperature and pressure. What is the molecular formula of the compound?

THIS IS THE END OF THE PAPER. CHECK YOUR WORK. MAKE SURE YOUR PAPER IS COMPLETE.