SECTION A: MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: Answer **ALL** questions in this section on the **ANSWER SHEET PROVIDED.** There is one mark for each of the questions on this section. Students may make any marks they wish on this section.

Questions 1-6 refer to the following molecular shapes. (Each shape may be used once, more than once, or not at all.)

A V-shaped
B Triangular planar
C Tetrahedral
D Pyramidal
E Linear

Use VSEPR to predict the shapes of these molecules

1. SO_3
2. CO_2
3. H_2O
4. CF_4
5. BCl_3
6. PCl_3

Questions 7-11 refer to the ground state electronic configurations of five elements A to E. (Each configuration may be used once, more than once, or not at all.)

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 covalent chloride of formula XCl_4
11. is an alkali metal

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

13) Which one of the following contains the least number of molecules?
A 10g of sulfur dioxide, SO_2.
B 10g of carbon dioxide, CO_2.
C 10g of ethanal, CH_3CHO.
D 10g of calcium hydride, CaH_2.
E 10g of ethanol, CH_3CH_2OH

14) Which one of the following does **NOT** have the same total number of electrons as the others?
A CH_4
B HF
C NH_4^+
D H_3O^+
E H_2S

15) Which of the following atoms in its ground state contains no unpaired electrons?
A lithium
B beryllium
C boron
D carbon
E oxygen

16) Which one of the following molecules has zero dipole moment?
A HCl
B F_2
C CH_2Cl_2
D CH_3Cl
E NCl_3

17) Copper metal reacts with silver nitrate solution according to the following equation:

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

If 0.10mol of copper is mixed with 0.10mol of silver nitrate in solution, then:
A 0.10mol of copper dissolves.
B 0.10mol of silver is precipitated.
C 2mol of silver are precipitated.
D 1mol of copper is dissolved.
E 1mol of copper(II) nitrate is formed.

18) Which group of elements generally has the lowest ionization energy?
A group 8
B group 5
C group 3
D group 2
E group 1

19) Which one of the following elements has an endothermic first electron affinity?
A potassium
B fluorine
C oxygen
D chlorine
E neon

20) 300 cm^3 of a 2.00M solution of KNO_3 is mixed with 200 cm^3 of water. The concentration of the resulting solution is
A 1.20M
B 3.33M
C 1.33 M
D 3.00M
E 5.00M

21) The enthalpy changes for the following process are:
$\frac{1}{4}C(g) \rightarrow \frac{1}{4}C(s)$ $\Delta H = -179$ kJ mol^{-1}
$H(g) \rightarrow \frac{1}{2}H_2(g)$ $\Delta H = -218$ kJ mol^{-1}
$\frac{1}{4}C(s) + \frac{1}{2}H_2(g) \rightarrow \frac{1}{4}CH_4(g)$ $\Delta H = -19$ kJ mol^{-1}
The mean enthalpy change for the formation of one mole of C-H bonds from gaseous carbon and atomic hydrogen in kJ is therefore:
A +416
B -397
C +237
D +378
E -416

22) The ionization energy of an atom is a measure of:
A The tendency of an atom to gain an electron.
B The tendency of an atom to lose all its electrons.
C The tendency of an ion to turn into an atom.
D The tendency of an atom to lose an electron.
E The energy given out when an atom forms a complex ion.

23) A certain volume of oxygen gas (molar mass 32 g mol^{-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. What is the relative molecular mass of X?
A 112
B 64.0
C 56.0
D 36.5
E 28.0

24) X and Y are two gases which behave ideally. They do not react with each other. The mass of 1 dm^3 of X is twice that of 1 dm^3 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 1 dm^3 of X is twice the number of molecules in 1 dm^3 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.

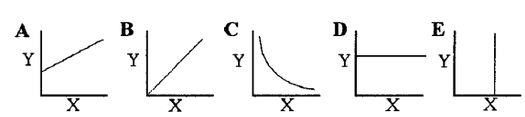
25) The kinetic theory equation may be stated as:

$$PV = \frac{1}{3}Nm\overline{u^2}$$

Which one of the following statements regarding this equation is true?
A The equation applies exactly to all gases.
B N represents the relative molecular mass of the gas.
C m represents the mass of a molecule of the gas.
D u represents the temperature of the gas.
E the bar over the u^2 term means "take the absolute value of".

26) The bond length in the H_2 molecule is 74pm and that in F_2 is 142pm. The bond length in the HF molecule in pm should therefore be:
A 108
B 216
C 68
D 74
E 142

Questions 27 to 31 involve the following graphs of Y against X:



Select the graph from A to E which is most appropriate in each case below. Each graph may be used once, more than once, or not at all.

27) A graph of pressure (Y) against volume (X) for a fixed mass of an ideal gas at constant temperature.
28) A graph of PV (Y) against pressure (X) for 1 mole of an ideal gas at constant temperature.
29) A graph of pressure (Y) against Celsius temperature (X) for a fixed mass of an ideal gas at constant volume.
30) A graph of volume (Y) against Kelvin temperature (X) for a fixed mass of an ideal gas at constant pressure.

31) A graph of 1/V (Y) against P (X) for a fixed mass of gas at constant temperature.

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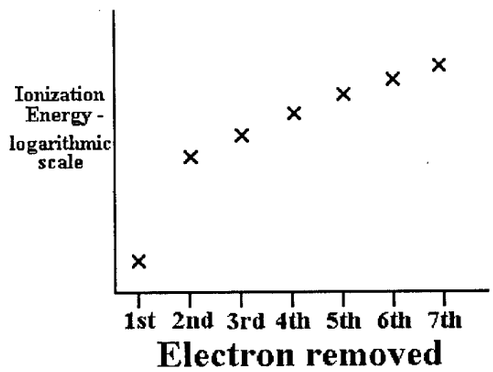
32) The graph below



could refer to which one of the following atoms?

A hydrogen
B lithium
C sodium
D magnesium
E aluminium

33) If, for an electron in an atom the principal quantum number, n, = 4 then the angular quantum number, l, may have:

A 1 value
B 2 values
C 3 values
D 4 values
E 5 values

34) Which one of the following is NOT a correct description of a p-orbital?

A It is a region of space where an electron is likely to be found.
B It is a solution of the Schrödinger equation.
C It has an angular node.
D It can contain 6 electrons.
E It is one of a set of three degenerate orbitals.

35) In a transition series of elements the atoms generally have:

A an incomplete s-orbital
B an incomplete p-subshell
C an incomplete d-subshell
D a full set of s- and p-orbitals
E a full set of p- and d-orbitals.

36) The screening effect is a term used to describe

A the effect of intervening electrons on the nuclear charge as "seen" by an outer electron.
B the effect the principal quantum number has on the energy of an electron.
C the increase in nuclear charge across a period of the periodic table.
D the decrease in electronegativity down a group of the periodic table.
E the increase in size of an atom when it accepts an extra electron.

37) The electron affinity of an atom is a measure of its tendency to.

A lose electrons.
B gain an electron.
C form a covalent bond.
D combine with other atoms.
E its electronegativity.

38) Covalent bonding is a result of

A the overlapping of atomic orbitals.
B merging of atomic nuclei.
C transfer of electrons.
D acceptance of protons.
E a metal reacting with a non-metal.

39) The percentage by mass of calcium in calcium carbonate is closest to:

A 25%
B 57%
C 40%
D 2.5%
E 5%

40) When nitrogen reacts with hydrogen to form ammonia the ratio of volumes reacting and produced (all volumes being measured at s.t.p.) is respectively:

A 1:3:1
B 3:1:1
C 1:1:1
D 1:3:2
E 2:1:3

SECTION II: Structured Questions

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

1) This question concerns various aspects of the properties of gases.

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

ii) A flask of volume 400 cm^3 contains a gas, A, at 80.0 mmHg. A second flask, B, of volume 800 cm^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)

b) A mixture 1 mole of oxygen and 1 mole of sulfur dioxide is allowed to effuse through a small hole.

i) Briefly state a relationship between the molar mass of a gas and its rate of effusion. (1)

ii) Which gas effuses the most rapidly, the oxygen or the sulfur dioxide.? (1)

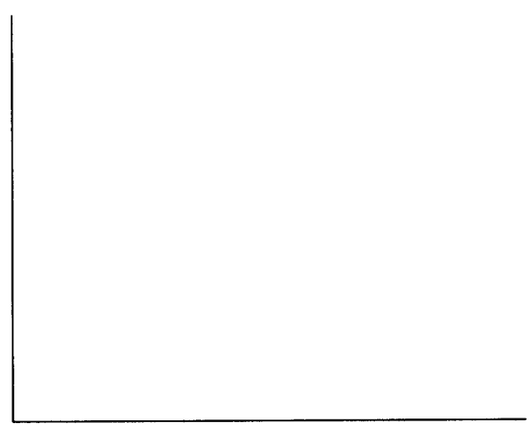
iii) Which gas is more prevalent in the mixture passing through the hole to begin with? (1)

iv) Calculate the relative numbers of moles of the two gases in the initial mixture passing through the hole. (2)

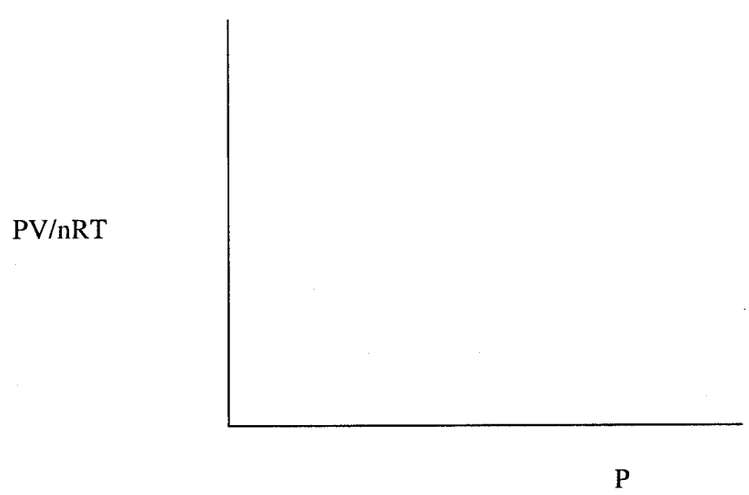
c) 1.56 dm^3 of a gas is collected over water at 25°C and a barometric pressure of 758 mmHg. If the mass of the gas is 2.02g and the vapour pressure of water at 25°C is 23.5 mmHg, find the molar mass of the gas.

(4)

d) i) 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)



e) On the axes below sketch a graph of PV/nRT against pressure, P, for (i) an ideal gas, and (ii) a real gas such as ammonia. (3)



2) a) Define the terms:

i) Standard enthalpy of formation. (2)

ii) Standard enthalpy of combustion. (2)

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)

3) Give explanations in terms of chemical theory for ANY FOUR of the following statements: (3 marks each part)

a) Covalent molecular compounds have low boiling and melting points

b) Water has a higher boiling point than hydrogen sulphide.

c) Metals are good conductors of electricity.

d) All the bond lengths and angles in the nitrate ion (NO_3^-) are equal although a Lewis structure shows one double and two single bonds.

e) The ionization energies of the elements in a group tend to decrease down the group.

f) The radius of the atoms in a period tend to decrease from left to right.

4) $20cm^3$ of a gaseous hydrocarbon were mixed with $120cm^3$ of oxygen (more than enough to react). The mixture was sparked to start the combustion and after completion of the reaction the volume was found to be $90cm^3$. This was reduced to $50cm^3$ following treatment of the mixture with potassium hydroxide.

a) Write a general equation showing states for the complete combustion of a hydrocarbon (C_xH_y). (2)

b) Write an equation showing states for the reaction of carbon dioxide with a solution of potassium hydroxide. (1)

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c) If the conditions of measurement were the same throughout, find the formula of the hydrocarbon. (4)

d) What *type* of formula does this calculation give? (1)

5) The following question concerns solutions and titrations.

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

ii) What is meant by the term "concordant titres"? (2)

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. (4)

b) What is the molarity of a solution of H_2SO_4 if 42.7 cm^3 of it is required to exactly titrate 27.5 cm^3 of 0.612 M NaOH solution? (4)