1. How many elements are there in the periodic table which form diatomic gaseous molecules in the form of X_2 at the room temperature?
   i. 3   ii. 4   iii.5   iv.6   v. 7

2. What is the total number of unpaired electrons in the V^{3+} ion formed by V of atomic number 23?
   i. 0   ii. 2   iii. 3   iv.4   v. 7

3. A mixture of the gases CH_4 and He exists in a rigid vessel at 200 K. Mass percentage of He in the mixture is 4%. What is the volume percentage of He in the mixture?
   i. 14.3%   ii. 28.3%   iii. 40%   iv. 60.5%   v. 85.7%

4. Out of the following molecules/ions which has a different shape compared with the others?
   i. F_2O ii. O_3 iii. HOCl   iv. IF_2^- v. NH_2^-

5. In a certain reaction, $\Delta H^\theta = 40$ kJ mol^{-1} and $\Delta S^\theta = 0.2$ kJ mol^{-1}K^{-1}. If ΔH and ΔS do not change with temperature, find the minimum temperature at which this reaction will be spontaneous?
   i. 200K   ii. 400K   iii. 500K   iv. 600K   v. 2000K

6. Which of the following shows the correct arrangement of the species in the increasing order of the radii?
   i. $O^{2-} < F^- < Na^+ < Mg^{2+}$ ii. $Na^+ < Mg^{2+} < O^{2-} < F^-$ iii. $Mg^{2+} < Na^+ < F^- < O^{2-}$
   iv. $F^- < O^{2-} < Na^+ < Mg^{2+}$ v. $Na^+ < Mg^{2+} < F^- < O^{2-}$

7. A brown gas evolves when a certain solid mixture is heated. When excess dilute H_2SO_4 is added to the residue solid mixture, a brown gas evolves again and a white colour precipitate was left in the solution. The compounds present in the solid mixture should be.
   i. $LiNO_3$ and $Mg(NO_3)_2$ ii. $NaNO_3$ and $Mg(NO_3)_2$
   iii. $NaNO_3$ and $LiNO_3$ iv. $NaNO_3$ and $Sr(NO_3)_2$
   v. $Mg(NO_3)_2$ and $Sr(NO_3)_2$

8. Which of the following responses most correctly shows the products obtained when Mg metal is heated with NH_3?
   i. $Mg(NH_2)_2, H_2$ ii. Mg_3N_2, H_2 iii. MgO, Mg_3N_2
   iv. $Mg(NH_2)_2, N_2$ v. MgH_2, N_2

9. The amount of SO_4^{2-} ions in an aqueous solution containing only $CuSO_4$ and $Cr_2(SO_4)_3$ is 800 ppm. The $Cu^{2+}: Cr^{3+}$ molar ratio is 1:1. The concentration of $Cr_2(SO_4)_3$ in the solution is, (S=32, O=16)

    i. 5.0×10^{-3} mol dm^{-3} ii. 2.0×10^{-3} mol dm^{-3} iii. 2.5×10^{-3} mol dm^{-3}

    iv. 3.0×10^{-3} mol dm^{-3} v. 1.6×10^{-3} mol dm^{-3}

10. From a sample of $(NH_4)_2 Fe (SO_4)_2.12H_2O$ (molar mass 500 g mol^{-1}), x g was dissolved completely in dilute H_2SO_4 acid and an aqueous solution of volume 250 cm^3 was prepared. 20.00cm^3 of 0.02mol dm^{-3} $K_2Cr_2O_7$ solution was required to completely react with 25.00cm^3 of this solution. What is the value of x?

    i. 1.2   ii. 2.0   iii. 2.4   iv. 12   v. 24

11. Volume of a rigid vessel containing a gaseous mixture of C_2H_6 and C_2H_4 is 8.314 dm^3. At 400 K, the pressure of the vessel is 8×10^5 Pa. 208 g of O_2 gas was required to completely burn this gaseous mixture. The initial mole fraction of C_2H_4 is, (O =16)

    i. $\frac{1}{2}$ ii. $\frac{1}{3}$ iii. $\frac{2}{3}$ iv. $\frac{1}{4}$ v. $\frac{1}{5}$

12. Which of the following is true regarding an electron with azimuthal quantum number $l = 2$?
    i.   The spin quantum number of the electron must be $m_s = +\frac{1}{2}$.
    ii.   The electron is present in a spherical orbital.
    iii.   The electron should be present in a 3p orbital.
    iv.   The electron is present in the second main energy level.
    v.   The magnetic quantum number of the electron can be $m_l = -2$.

13. An aqueous solution called X was heated after adding NaOH and Al powder and NH_3 gas evolves during the experiment. Consider the following statements regarding the solution X.
    A) Contains NO_3^- ions
    B) Contains NO_2^- ions
    C) Contains NH_4^+ ions
    The correct statement/s is/are?

    i. Only A   ii. Only B   iii. Only C

    iv. All A, B and C   v. One or more statements out of A, B and C

14. The wavelength of an infra-red wave emitted from a television remote control is 1500 nm. Find the energy of a photon of this radiation. (Speed of light 3×10^8 m s^{-1}, h $=6.626 \times 10^{-34}$ Js)

    i. 1.325×10^{-34} J   ii. 1.325×10^{-27} J   iii. 1.325×10^{-19} J

    iv. 1.325×10^{-11} J   v. 1.325×10^{28} J

Follow the instructions given below for the questions from 15 to 20.

(1)	(2)	(3)	(4)	(5)
If only (*a*) and (*b*) are correct.	If only (*b*) and (*c*) are correct.	If only (*c*) and (*d*) are correct.	If only (*d*) and (*a*) are correct.	If any other number or combination of response is correct.

15. Which of the following reactions give NH_3 gas as a product?
    a. Reaction between NH_4Cl and $Ba(OH)_2$
    b. Reaction of Ca_3N_2 and water
    c. Thermal decomposition of NH_4NO_3
    d. Reaction of $NaNO_2$ with dilute HCl

16. Which of the following statement/s about the atomic spectrum of Hydrogen is/are not true?

    a) The energy difference between the $n = \infty$ and $n = 1$ levels is the ionization energy of H.

    b) The transition from $n = 4$ to $n = 2$ corresponds to line H_β.

    c) The energy difference between $n = 2$ and $n = 1$ levels is smaller than that between $n = 3$ and $n = 2$ levels.

    d) Each line in the spectrum corresponds to an energy level of the H atom.

17. Which of the following statements is true about the formation of a suitable covalent bond?

    a) An orbital with 2 electrons overlaps with an orbital with no electrons.
    b) An sp^2 bonding orbital overlaps with another sp^2 bonding orbitals to form an π bond.
    c) An sp^2 bonding orbital overlaps with an sp bonding orbital to form an π bond.
    d) An sp^2 bonding orbital overlaps with an sp bonding orbital to form an σ bond

18. A molecule of a compound Whose molecular formula is AX_3 can be shaped like?

    a) Trigonal pyramid   b) T shape
    c) Angular   d) Trigonal planar

19. ΔH value is (-) for which of the following reactions?

    a) $NaBr(s) \rightarrow Na^+(g) + Br^-(g)$ b) $\frac{1}{2}Br_2(g) \rightarrow \frac{1}{2}Br_2(l)$

    c) $Br(g) + e \rightarrow Br^-(g)$ d) $Br^-(g) + e \rightarrow Br^{2-}(g)$

20. Incorrect statement regarding molality is,
    a. An extensive property   b. An intensive property

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c. Depends on the temperature   d. The number of moles of solute in a unit mass of the solution

Follow the instructions given below for the questions from 21 to 25.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second Statement
21	The reaction between LiH and D_2O gives HD.	LiH has the hydride anion and D_2O supplies D^+ to the reaction.
22	Entropy of the surrounding environment increases as water vapor in a closed container condenses.	The heat absorbed by a closed system increases the thermal energy of the surrounding environment.
23	CaO(s) is more ionic than MgO(s).	A cation has the ability to distort the electron cloud of an anion.
24	When NH_4NO_3 undergoes thermal decomposition, NH_4^+ ion is oxidized and the NO_3^- ion is reduced.	Thermal decomposition of NH_4NO_3 is a disproportionation reaction.
25	Standardization a solution of $Na_2S_2O_3$ using KIO_3 and H^+/KI	Reaction of KIO_3 and H^+/KI gives I_2.

4

Structured Essay

1. a)

    (i) For the following compounds, arrange the corresponding characteristic in increasing order. (Reasons are not required)

    1). N_2O, NO_2, NO_2Cl, NO_2^- (electronegativity of N atom)

    …………......< …………..…..<………......…<……………...

    2). CO_2, CO_3^{2-}, CO, $HCOO^-$ (C-O bond energy)

    …………....<…………..…..<………......…<……………..

    3). CCl_4, CH_3Cl, CH_4, CH_3OH (boiling point)

    …………..…......<………..………….<………...............…<………………....

    4). SO_2, SO_3, SO_3^{2-}, HSO_4^- (bond length of O-S-O)

    …………..…......<………..………….<………...............…<………………....

    5). Na, Cl, F, O (First ionization enthalpy)

    …………..…......<………..………….<………...............…<………………....

    b)

    (i) CNO_3^- ion has only one carbon atom and only one oxygen atoms attached to the N atom. Draw the most acceptable Lewis dot-dash structure for the CNO_3^- ion.

    (ii) Following showed the most acceptable Lewis structure for the N_4CH_2O ion. Draw two other Lewis structures for this compound. State their relative stability.

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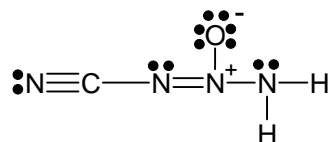
(iii) Complete the given table based on the hypothetical Lewis dot dash structure and its skeleton given below.
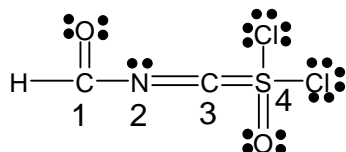
		C^1	N^2	C^3	S^4
i	VSEPR pairs around the atom				
ii	Electron pair geometry around the atom				
iii	Shape around the atom				
iv	Hybridization of the atom				

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure drawn in part (iii) above. [numbering of atoms is as in part (iii)].

I. $H – C^1$ H …………………………… C^1 ……………………………...

II. $C^1 – N^2$ C^1 …………………………… N^2 ……………………………...

III. $N^2 – C^3$ N^2 …………………………… C^3 ……………………………...

IV. $C^3 – S^4$ C^3 …………………………… S^4 ……………………………...

V. $S^4 – Cl$ S^4 ……………………………   Cl ……………………………..

(v) Identify the atomic orbitals involved in the formation of following π bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms in part (iii))

I $N^2 – C^3$ N^2 ………………………… C^3 …………………………

II $C^3 – S^4$ C^3 ………………………… S^4 …………………………

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c) The HBr molecule has a dipole movement of 2.60D. Bond length of H-Br is 141 pm. Calculate the percentage of ionicity of HBr. $1D=3.34\times10^{-30}$ Cm, The charge of the electron= 1.6×10^{-19} C

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2.

  a) The reaction between NH_3 and O_2 is very slow and is negligible at room temperature. 9 mol of NH_3 and 9 mol of N_2 gases were added to a rigid vessel having a volume of 2 dm^3 and room temperature at 27 °C. The vessel was heated until the temperature reached 227 °C and then Pt powder was added to it. Then the reaction is rapid and continues until it is completed.

   Equations for the reaction,

$$4NH_3(g) +5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$
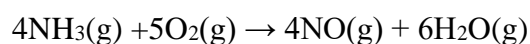
  (i)   What is the pressure inside the container at room temperature?

  (ii)   What is the pressure in the vessel at 227 °C? (After the reaction is completed)

  (iii)   Calculate the mole fractions of each gas remaining in the vessel at 227 °C.

  (iv)   Calculate the partial pressures of each gas remaining in the vessel at 227 °C.

  (v)   6 mol of He gas was added to the vessel at 227 °C. Calculate the pressure inside the container? Express the increase in pressure as a percentage.

  (vi)   Calculate the partial pressure of each gas after adding He.

  b)

  (i)   Define following enthalpy changes.

       I.   Standard enthalpy of formation

       II.   Standard enthalpy of lattice dissociation

  (ii)   Find the standard lattice dissociation enthalpy of $PbCl_2(s)$ using the data below. Use an enthalpy level diagram for your calculation.

Standard enthalpy of atomization of Pb(s)	+195 kJ mol^{-1}
Standard enthalpy of first ionization of Pb(g)	+715 kJ mol^{-1}
Standard enthalpy of second ionization of Pb(g)	+1450 kJ mol^{-1}

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Standard enthalpy of bond dissociation of $Cl_2(g)$ +242 kJ mol^{-1}

Standard enthalpy of first electron gain of $Cl(g)$ -364 kJ mol^{-1}

Standard enthalpy of formation of $PbCl_2(s)$ -360 kJ mol^{-1}