Code : 100103/100203

B.Tech 2nd Semester Special Exam., 2020

(New Course)

CHEMISTRY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Answer any *seven* questions in brief : 2×7=14

(a) Arrange the following in increasing order of stability :

$$N_2,\ N_2^+,\ N_2^-,\ N_2^{2-}$$

(b) Transition metal ions like Cu^+ and Ag^+ are colourless. Why?

(c) Which of Cr^+ or Cu^+ is expected to be coloured?

(d) ^{13}C is NMR active, but ^{12}C is not. Why?

(e) What is the direction of a reaction when $\Delta G = 0$?

(f) Why is work not a state function?

(g) Write the relationship between parts per million (ppm) and Clarke's degree (°Cl).

(h) What is critical temperature of a gas?

(i) Arrange the following ligands in order of increasing field strength :

$$CN^-,\ CO,\ H_2O,\ NH_3$$

(j) Arrange the following in order of their increasing reactivity in nucleophilic substitution reaction :

$$CH_3F,\ CH_3I,\ CH_3Br,\ CH_3Cl$$

2. *(a)* At what temperature will water boil when the applied pressure is 528 mm of Hg? (Latent heat of vaporisation of water = 545·5 cal/g) 4

(b) At NTP, 2·8 L of O_2 were mixed with 19·6 L of H_2. Calculate the increase in entropy (assume ideal gas behaviour). 4

(c) The equilibrium constants for the reaction $H_2(g) + S(s) \rightleftharpoons H_2S(g)$ are 18·5 at 925 K and 9·25 at 1000 K. Calculate standard enthalpy of the reaction. Also calculate ΔG° and ΔS° at 925 K. 6

3. (a) The uncertainties in the position and velocity of a particle are $9{\cdot}5 \times 10^{-10}$ m and $5{\cdot}5 \times 10^{-20}$ ms^{-1}, respectively. Calculate the mass of the particle. ($h = 6{\cdot}626 \times 10^{-34}$ J-s) 4

(b) Calculate the kinetic energy of a moving electron which has a wavelength of 4·8 pm. (Mass of electron = $9{\cdot}11 \times 10^{-31}$ kg) 5

(c) Discuss the failures of classical mechanics to explain properties of particles at atomic and sub-atomic levels. 5

4. (a) Draw the MO energy-level diagram for O_2 and based on the diagram, and explain the magnetic property observed in O_2, O_2^+ and O_2^-. 8

(b) Explain geometrical isomerism and optical isomerism for transition metal complex with an example for each. 6

5. (a) The internuclear distance of NaCl is $2{\cdot}36 \times 10^{-10}$ m. Calculate the reduced mass and moment of inertia of NaCl. (Atomic mass of Cl = 35×10^{-3} kg mol^{-1} and Na = 23×10^{-3} kg mol^{-1}) 4

(b) Calculate the force constant for CO, if it absorbs at $2{\cdot}143 \times 10^5$ m^{-1}. (Atomic mass of C = 12×10^{-3} kg mol^{-1} and O = 16×10^{-3} kg mol^{-1}) 4

(c) How many ^{1}H NMR signals are there in —

(i) $CH_3{-}{-}CH_3$;

(ii) $CH_3{-}{-}CH_2{-}{-}CH_3$;

(iii) $CH_3{-}CH_2{-}{-}Cl$;

(iv) $CH_3{-}CHCl{-}{-}CH_3$;

(v) $C_6H_5CH_3$;

(vi) $C_6H_5CH_2CH_3$? 6

(Continued)

6. *(a)* 2 mols of NH_3 at 300 K occupy a volume of 5×10^{-3} m^3. Calculate the pressure using van der Waals equation [$a = 0{\cdot}417$ N m^4 mol^{-2} and $b = 0{\cdot}037 \times 10^{-3}$ m^3 mol^{-1}]. Compare the above result with the pressure calculated using ideal gas equation. 5

(b) Write short notes on the following : 9

(i) Magnetic resonance imaging

(ii) Fingerprint region in infrared spectroscopy

(iii) Different types of electronic excitations

7. *(a)* Consider the following half-cell reactions :

$$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e \rightarrow PbSO_4(s) + 2H_2O,\ E^\circ = 1{\cdot}70\ V$$

$$PbSO_4(s) + 2e \rightarrow Pb(s) + SO_4^{2-}(aq),\ E^\circ = -0{\cdot}31\ V$$

Write the cell (in proper cell notation) and the cell reaction. Calculate the value of E° for the cell and the EMF generated if $[H^+] = 0{\cdot}1\ M$ and $[SO_4^{2-}] = 2\ M$. 7

(Turn Over)

(b) A water sample had the following constituents per litre :

$CaCO_3$ = 81 mg, $MgHCO_3$ = 75 mg,
$CaSO_4$ = 136 mg, $MgSO_4$ = 120 mg,
NaCl = 4·7 mg

Calculate the quantity of temporary and permanent hardness in the water sample. Calculate the quantity of lime (78% purity) and soda (92% purity) required for softening of 1·5 million litres of the above water sample. 7

8. *(a)* Describe two methods used for resolving racemic mixtures into optically active compounds. 4

(b) Write the possible optical isomers of tartaric acid and indicate the point of symmetry or plane of symmetry (if any) in the isomers. 5

(c) Differentiate between *(i)* enantiomers and diastereomers and *(ii)* racemic mixture and *meso* compounds. 5

9. *(a)* How do you decide whether the reaction $CH_3Br + OH^- \rightleftharpoons CH_3OH + Br^-$ proceeds by S_N1 or S_N2 reaction? Give justification in favour of your answer. 4

(Continued)

(b) Draw the energy profile diagram for the following reaction : 4

$$(CH_3)_3CBr + OH^- \rightleftharpoons (CH_3)_3COH + Br^-$$

(c) Write short notes on the following : 6

(i) Steric effects

(ii) Diels-Alder reaction

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