L-1/T-2/MME Date : 03/11/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **CHEM 135** (Inorganic Chemistry)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Why is the Arrhenius acid-base definition too limited? Which acid/base theory or theories could be applied to explain the behavior of SO_2 in an aqueous solution? **(10)**

   (b) Use frontier molecular orbital theory to explain the following observations (i) water can act as an oxidizing agent; (ii) water can act as a reducing agent. **(10)**

   (c) Justify the following statement: "BF_3 is an acid but NH_3 is a base". **(10)**

   (d) How molecular orbital formation is a linear combination of atomic orbitals? **(5)**

2. (a) Utilize the molecular orbital diagram for carbon monoxide to explain the Lewis basicity of this molecule. **(10)**

   (b) Explain (i) coordination of thiocyanate to Hg^{2+} (ii) AgF is the most soluble silver halide, but LiF is the least soluble among the lithium halides. **(10)**

   (c) "Hard acids tend to bind to hard bases, and soft acids tend to bind to soft bases" justify with the help of appropriate examples. **(10)**

   (d) How the energy gap between HOMO of Lewis base and LUMO of Lewis acid determines adduct formation? **(5)**

3. (a) What are the advantages of having a transition metal ion at the active site of an enzyme? Give systematic names for the following formulas (i) $[Cu(NH_3)_4]^{2+}$ (ii) $[PtCl_4]^{2-}$ (iii) $[Mn(CN)_6]^{4-}$ and (iv) $[Cr(NH_3)_6][Cr(CN)_6]$. **(10)**

   (b) Draw all the possible stereoisomers of $[MA_3B_3]$, $[MA_2(B\text{-}B)_2]$ and $M(B\text{-}B)_3$, where A and B are the monodentate and B-B is the bidentate symmetrical ligand. **(10)**

   (c) For each of the complex given here, predict its hybridization, structure, the number of unpaired electrons present and whether it is high spin or low spin (i) $[TiCl_6]^{3-}$ and (ii) $[CoCl_4]^{2-}$ according to VBT. **(10)**

   (d) How can CFT explain the color of a transition-metal complex? **(5)**

Contd P/2

CHEM 135/MME

4. (a) Solutions of the complexes $[Co(NH_3)_6]^{2+}$, $[Co(OH_2)_6]^{2+}$ (both octahedral), and $[CoCl_4]^{2-}$ are colored. One is pink, another is yellow, and the third is blue. Considering the spectrochemical series and the relative magnitudes of $\Delta_{Tetrahedral}$ and $\Delta_{Octahedral}$, assign each color to one of the complexes. **(10)**

(b) Apply your knowledge of LFT on $\Delta_{Octahedral}$ to explain the weak and strong field nature observed for π-donor, σ-only and π-acceptor ligands. **(10)**

(c) Employ Jahn-Teller effect to explain the following observation: "The Cu ion in $[Cu(H_2O)_6]^{2+}$ has a d^9 configuration but instead of one d-d transition, two d-d transitions were observed in the absorption spectra." **(10)**

(d) Fe(II) forms the complex ion $[Fe(OH)_4]^{2-}$ through equilibrium reactions in which hydroxide replaces water in a stepwise manner. If log K_1 = 5.56, lgo K_2 = 4.21, log K_3 = –0.10, and log K_4 = –1.09, what is K_f? Do you expect the $[Fe(OH)_4]^{2-}$ complex to be stable? **(5)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Explain the process of emission of light by an atom. Calculate the frequency of the spectral line emitted when the electron in n = 3 in hydrogen atom de-excites to ground state (Rydberg constant = 109737 cm^{-1}). **(10)**

(b) Derive Schrödinger wave equation and define all the terms involved in it. **(15)**

(c) What do you understand by shielding effect? Explain the factors affecting it. Give its applications. **(10)**

6. (a) Define ionization energy. The first ionization energy of the chlorine atom is 1251 kJ/mol. State which of the following values would be the more likely ionization energy value of the iodine atom. Explain. **(10)**

(i) 1000 kJ/mol (ii) 1400 kJ/mol

(b) For each of the following, use formal charges to choose the Lewis formula that gives the best description of the electron distribution: **(10)**

(i) ClO_3^-, (ii) SO_2

(c) Define bond energy and bond length. What is the relationship between bond energy and bond length. Draw and describe a potential energy diagram for a molecule such as Cl_2. Indicate the bond length (194 pm) and the bond dissociation energy (240 kJ/mol). **(15)**

Contd P/3

CHEM 135/MME

7. (a) Explain why the salts of alkaline earth metals with mononegative ions tend to be soluble, while those with dinegative ions tend to be insoluble. **(10)**

   (b) Lithium salts are often much less soluble in water than the corresponding salts of other alkali metals. How would you explain this behavior? **(10)**

   (c) Draw the Lewis structure of XeF_4. Describe the bonding in XeF_4 using hybrid orbitals. **(15)**

8. (a) The oxygen-oxygen bond in O_2^+ is 112 pm and in O_2 is 121 pm. Explain why the bond length in O_2^+ is shorter than in O_2. Would you expect the bond length in O_2^- to be longer or shorter than that in O_2? Why? **(10)**

   (b) What are the necessary conditions for an effective combination of two atomic orbitals to form molecular orbitals? Construct MO diagram for O_2 molecule and answer the following: **(15)**

   (i) Calculate the bond order in O_2 and O_2^+ ion.

   (ii) What would be the magnetic character of O_2 molecule?

   (c) The ionization energy of O_2 molecule is less than that of O_2^+. Explain it by molecular orbital theory. **(10)**

L-1/T-2/MME **Date: 19/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **ME 141** (Engineering Mechanics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Symbols used here usual meaning and interpretation.

1. (a) At the instant shown in Fig. for Q. 1(a), slider block *B* is moving with a constant acceleration, and its speed is 150 mm/s. Knowing that after slider block *A* has moved 240 mm to the right its velocity is 60 mm/s, determine (i) the accelerations of *A* and *B*, (ii) the acceleration of portion *D* of the cable, (iii) the velocity and the change in position of slider block *B* after 4 s. **(17)**

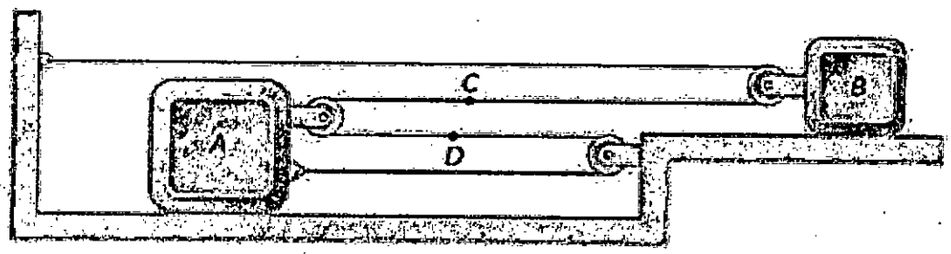

Fig. for Q. 1(a)

(b) At the instant shown in Fig. for Q. 1(b), cars A and B are traveling at velocity of 40 m/s and 30 m/s, respectively. If B is increasing its velocity by 2 m/s^2, while A maintains a constant velocity, determine the velocity of B with respect to A. Also find acceleration of B. The radius of the curvature at B is $\rho = 200$ m. **(18)**

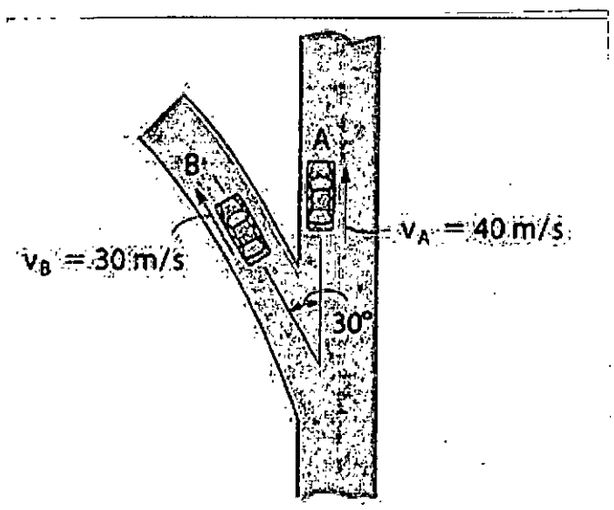

Fig. for Q. 1(b)

Contd P/2

ME 141/MME

2. (a) Two wires AC and *BC* are tied at *C* to a sphere which revolves at a constant speed '*V*' in the horizontal circle shown in Fig. for Q. 2(a). Determine the range of values of '*V*' for which both wires remain taut. **(15)**

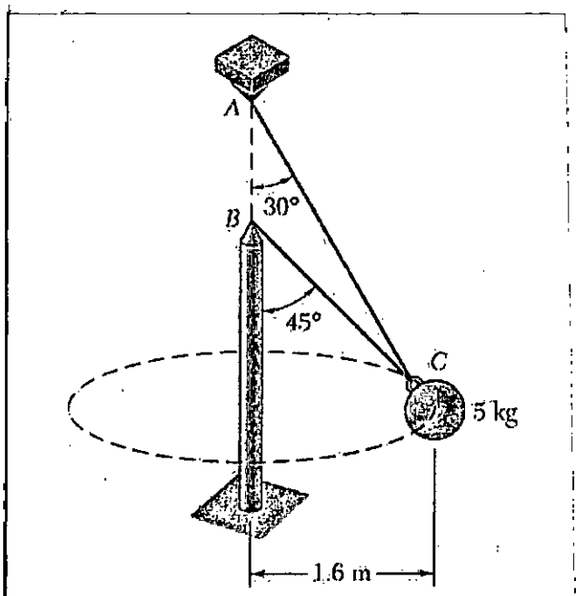

Fig. for Q. 2(a)

(b) Block *B* of mass 10-kg rests, as shown in Fig. for Q. 2(b), on the upper surface of a 22-kg wedge *A*. Knowing that the system is released from rest and neglecting friction, determine the acceleration of *B*. **(20)**

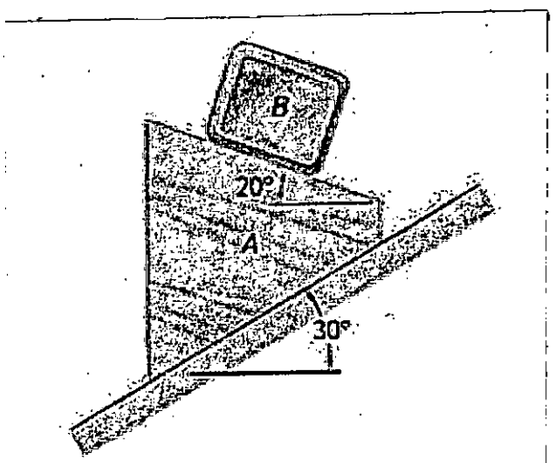

Fig. for Q. 2(b)

Contd P/3

ME 141/MME

3. (a) A 10-kg collar travels down a smooth slope as shown in Fig. for Q. 3(a). If at S_1 its speed is 20 m/s, determine its speed when it gets to S_2. The spring remains horizontal. It has an original length of 8 m and spring constant $k = 40$ N/m. **(17)**

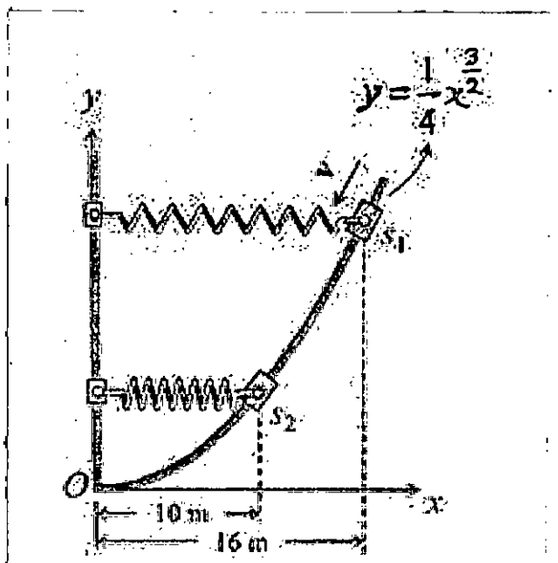

Fig. for Q. 3(a)

(b) Two smooth disks A and B each has a mass of 0.5 kg. If both disks are moving with the velocities shown in the Fig. for Q. 3(b) when they collide, determine their final velocities just after the collision. The coefficient of restitution is 0.7. **(18)**

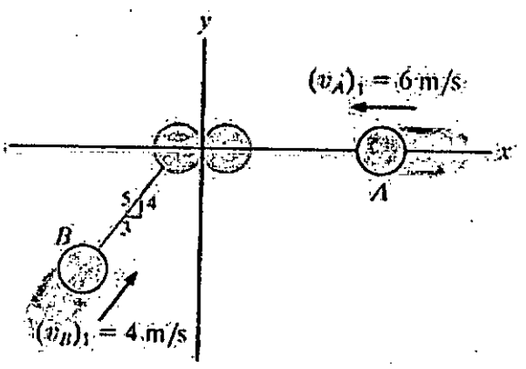

Fig. for Q. 3(b)

4. Knowing that at the instant shown in Fig. for Q. 4, bar AB has a constant angular velocity of 4 rad/s clockwise, determine the angular acceleration (i) of bar BD, (ii) of bar DE. **(35)**

Contd P/4

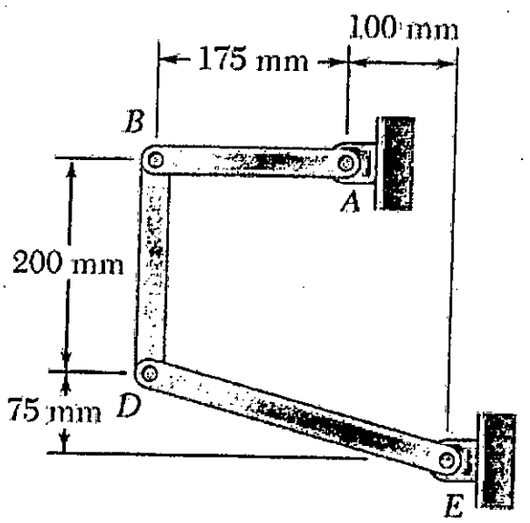

Fig. for Q. 4

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Symbols have their usual meaning.

5. (a) Three cables are used to tether a balloon as shown in Fig. 5(a). Determine the vertical force P exerted by the balloon at A knowing that the tension in cable AD is 481 N. **(17)**

(b) The coefficients of friction between the block and the rail, shown in Fig. 5(b), are $\mu_s = 0.30$ and $\mu_k = 0.25$. Knowing that $\theta = 65°$, determine the smallest value of P required (i) to start the block moving up the rail, (ii) to keep it from moving down. **(18)**

6. (a) The triangular plate ABC is supported by ball-and-socket joints at B and D and is held in the position shown (Fig. 6(a)) by cables AE and CF. If the force exerted by cable AE at A is 55 N, determine the moment of that force about the line joining points D and B. **(17)**

(b) The bar ABC as shown in Fig. 6(b) is held in the position shown by a hinge support at A and a roller support at B. A force of magnitude 100 N is applied at C. Determine the reactions at A and B when $\beta = 50°$. **(18)**

7. (a) A truss along with the loading acting on it is shown in Fig. 7(a). Determine the force in members CE, EF, and FH and state if the members are in tension or compression. **(17)**

(b) A frame is acted upon by a force at E as shown in Fig. 7(b). Determine the components of all forces acting on member $ABCD$ of the frame. **(18)**

8. (a) Determine the centroid of the plane area shown in Fig. 8(a). **(17)**

(b) A plane area bounded by two curves is shown in Fig. 8(b). Determine the moment of inertia and the radius of gyration of the area with respect to the x axis. **(18)**

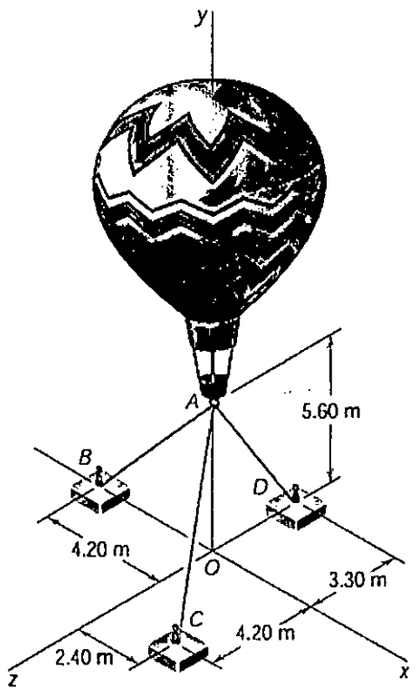

Fig. 5(a)

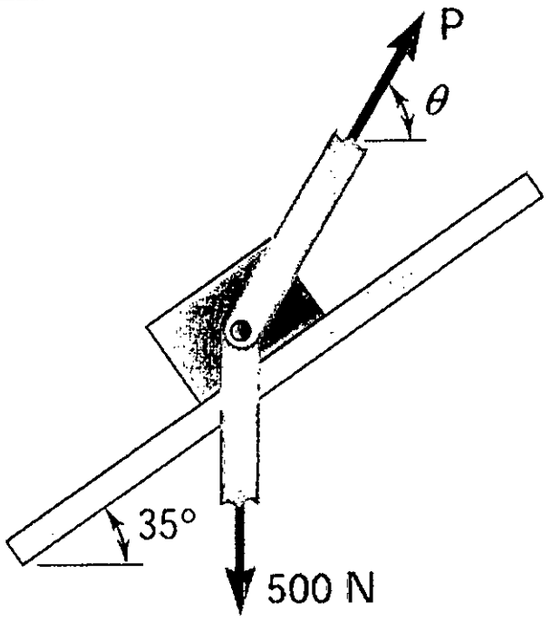

Fig. 5(b)

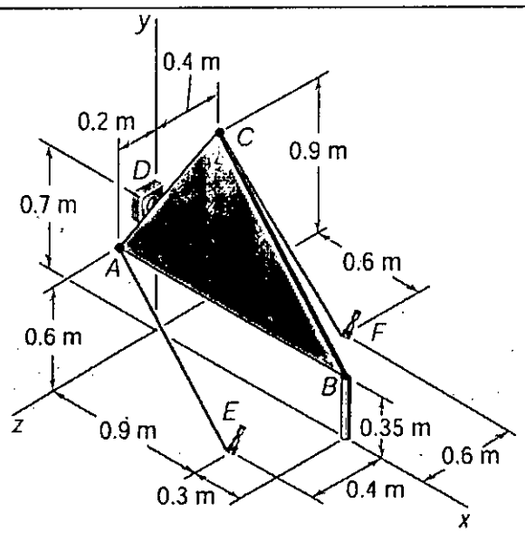

Fig. 6(a)

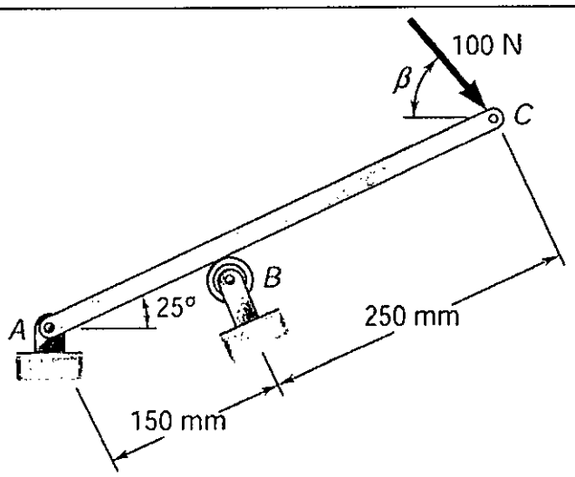

Fig. 6(b)

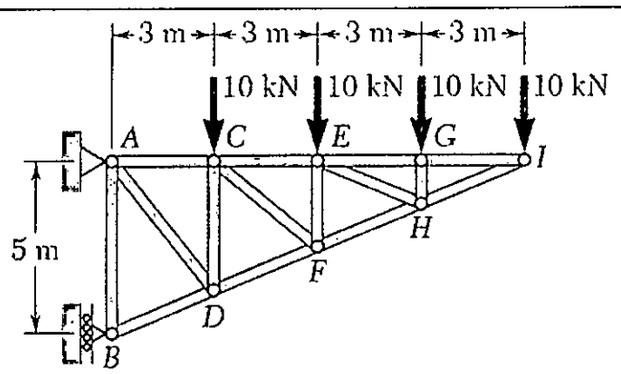

Fig. 7(a)

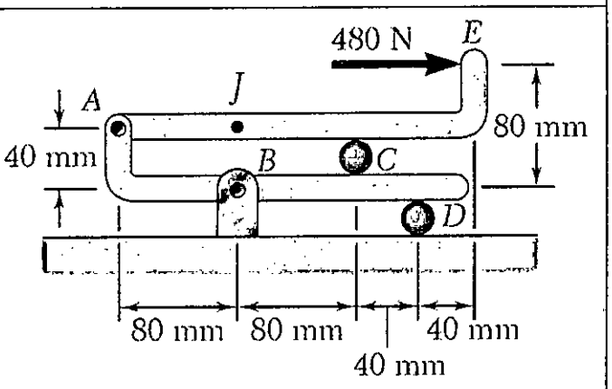

Fig. 7(b)

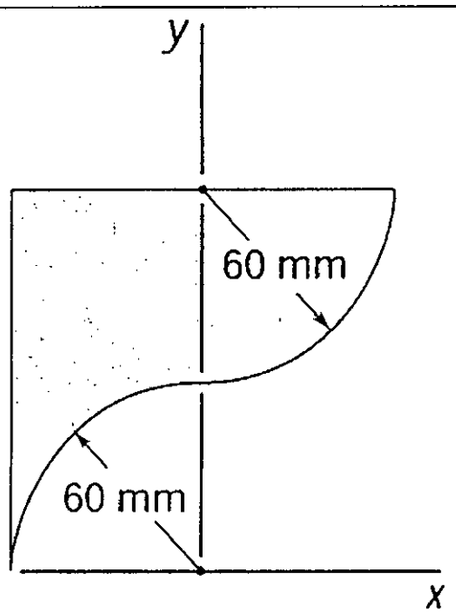

Fig. 8(a)

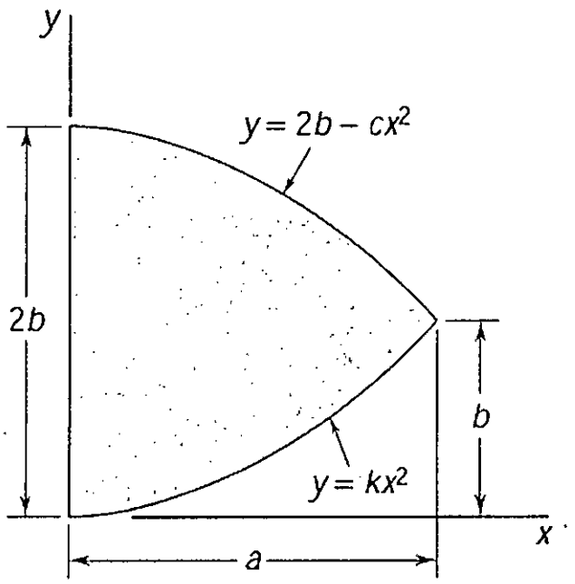

Fig. 8(b)

L-1/T-2/MME Date : 30/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **PHY 169** (Physics II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols have their usual meanings.

1. (a) What is meant by a beam? Explain the terms: neutral axis, neutral plane and bending moment of a beam. **(10)**

   (b) What is a cantilever? Obtain an expression for the depression of the free end of a cantilever fixed at one end and loaded at the other end. **(17)**

   (c) A uniform rod of length 1.0 m is clamped horizontally at one end. A weight of 0.1 kg is attached at the free end. Calculate the depression of the midpoint of the rod. The diameter of the rod is 0.02 m. **(8)**

2. (a) Discuss various form of energy possessed by a liquid in motion. **(10)**

   (b) What is venturimeter? Derive an expression for the rate of flow of a liquid through a pipe. **(17)**

   (c) A venturimeter has a main pipe of diameter 0.2 m and a throat of diameter 0.15 m. The levels of water column in the two limbs differ by 0.1 m. Calculate the amount of water discharged through the pipe in one hour. Density of water is 10^3 kg/m^3. **(8)**

3. (a) Explain the term surface energy. How is it related to surface tension? **(10)**

   (b) Derive an expression for the excess of pressure across a curved membrane. Discuss it for spherical and cylindrical surfaces. **(17)**

   (c) A spherical soap bubble of radius 0.01 m is formed inside another soap bubble of radius 0.02 m. Calculate the radius of a single soap-bubble which will have an excess of pressure equal to the difference in pressure between the inside of the inner bubble and the outside of the outer bubble. **(8)**

4. (a) Obtain an expression for pressure of a perfect gas in terms of density and root mean square velocity of the molecules. **(13)**

   (b) Define mean free path. Show that mean free path, $\lambda = \frac{RT}{\sqrt{2}\left(\pi d^2\right)PN_A}$, where the symbols have their usual meanings. **(10)**

   (c) State and prove the principle of equipartition of energy. For a gas possessing f degrees of freedom, find the ratio of the two specific heats. **(12)**

Contd P/2

PHY 169/MME

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Derive the Van der Waals' equation of state and give its graphical representation. **(19)**

(b) Define the variables P_r, T_r and V_r. Hence, obtain the reduced equation of state. The symbols have their usual meanings. **(12)**

(c) One mole of gas, stored at 273 K, occupies a volume of 5.5×10^{-4} m^3. Assuming it to be a Van der Waals' gas, calculate the pressure it exerts. Given $a = 0.37$ Nm^4 mol^{-2}, $b = 43 \times 10^{-6}$ m^3 mol^{-1} and $R = 8.31$ $Jmol^{-1}$ K^{-1}. **(4)**

6. (a) State and explain the first law of thermodynamics. Define internal energy. **(4)**

(b) Describe a Carnot's cycle by obtaining expressions for work done in each operation of the cycle. Hence deduce an expression for efficiency in terms of temperature. **(25)**

(c) A Carnot's engine whose temperature of the source is 400 K takes 200 calories of heat at this temperature and rejects 150 calories of heat to the sink. Find (i) temperature of the sink and (ii) efficiency of the engine. **(6)**

7. (a) Define lattice parameters in 3-D crystal system. What are the differences in lattice parameters of orthorhombic, tetragonal, and cubic crystal systems? **(7)**

(b) Draw a unit cell of zinc blend crystal and calculate the number of atom in the unit cell. **(10)**

(c) Show that for hexagonal close-packed structure the *c/a* is 1.633. Use this to calculate the atomic packing factor for this structure. Write down the similarities and differences between the cubic and hexagonal close packed structures. **(18)**

8 (a) What are Miller indices? A certain crystal has lattice parameters of 4.24, 10.00 and 3.66 Å on the X, Y, Z axes, respectively. Determine the Miller indices of a plane having intercepts of 2.12, 10.00 and 1.83 Å on the X, Y and Z axes. **(8)**

(b) Derive the Bragg's condition for X-ray diffraction. Briefly discuss about the basic methods of X-ray diffraction. **(14)**

(c) Classify crystal defects and describe two of them in short. **(6)**

(d) Differentiate conductor, semiconductor, and insulator in the light of band structure. What will happen to the Fermi energy level when impurities are added to an intrinsic semiconductor? **(7)**

L-1/T-2/MME **Date: 15/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 175** (Partial Differential Equations and Vector Analysis)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Show that any vector **r** can be represented as a linear combination of three non coplanar vectors **a, b, c**. Hence find a linear relation among the vectors (2, –3, 4), (1, –1, 1), (–1, 1, 1) and (1, 1, 1). **(12)**

   (b) Prove that, $[\mathbf{a}\times\mathbf{p}\ \mathbf{b}\times\mathbf{q}\ \mathbf{c}\times\mathbf{r}]+[\mathbf{a}\times\mathbf{q}\ \mathbf{b}\times\mathbf{r}\ \mathbf{c}\times\mathbf{p}]+[\mathbf{a}\times\mathbf{r}\ \mathbf{b}\times\mathbf{p}\ \mathbf{c}\times\mathbf{q}]=0$. **(12)**

   (c) Solve for **r**: $\mathbf{r}\times\mathbf{b}=\mathbf{a}$ where **a, b** are two given vectors such that **a** is perpendicular to **b**. **(11)**

2. (a) A particle moves along the curve $\mathbf{r} = (t^3-4t)\mathbf{i}+(t^2+4t)\mathbf{j}+(8t^2-3t^3)\mathbf{k}$ where t is the time. Find the magnitudes of the tangential and normal components of its acceleration when $t = 2$. **(11)**

   (b) Derive the Frenet-Serret formulae. **(12)**

   (c) Given the space curve $x = t,\ y = t^2,\ z = 3t^3$, find the curvature κ and the torsion τ at any point t. **(12)**

3. (a) Define normal and directional derivative. Find the values of the constants a, b, c so that the directional derivative of $\phi = axy^2 + byz + cz^2x^3$ at (1, 2, –1) has a maximum magnitude 64 in the direction parallel to x-axis. **(12)**

   (b) Find the equations for the tangent plane and normal line to the surface $\phi = x^2yz + 4xz^2$ at the point (1, –2, –1). **(12)**

   (c) Prove that, $\nabla\cdot\left(\frac{\mathbf{r}}{r^3}\right)=0$. **(11)**

4. (a) If $\mathbf{F} = 2xyz^2\mathbf{i}+(x^2z^2+z\cos yz)\mathbf{j}+(2x^2yz+y\cos yz)\mathbf{k}$, show hat $\int\mathbf{F}.d\mathbf{r}$ is independent of path. Find the work done in moving an object in the force field **F** from (0, 0, 1) to $\left(1,\frac{\pi}{4},2\right)$. **(11)**

   (b) Evaluate $\iint_S \mathbf{A}.\mathbf{n}dS$ over the entire surface S of the region bounded by the cylinder $x^2+z^2=9$, $x=0, y=0, z=0$ and $y=8$, if $\mathbf{A} = 6z\mathbf{i}+(2x+y)\mathbf{j}-x\mathbf{k}$. **(12)**

   (c) Evaluate $\iiint_V (2x+y)dV$ where V is the closed region bounded by **(12)**

   $$z = 4-x^2,\ x=0,\ y=0,\ y=2,\ z=0.$$

Contd P/2

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Use the Divergence theorem to find the outward flux of the vector field $\mathbf{F}(x,y,z)=x^3\mathbf{i}+y^3\mathbf{j}+z^3\mathbf{k}$ across the surface of the region that is enclosed by the circular cylinder $x^2+y^2=4$ and the planes $z=0$ and $z=3$. **(15)**

(b) Verify Stoke's theorem for the vector field $\mathbf{F}(x,y,z)=2z\mathbf{i}+3x\mathbf{j}+5y\mathbf{k}$, taking σ to be the portion of the paraboloid $z=4-x^2-y^2$ for which $z\geq 0$ with upward orientation, and C to be the positively oriented circle $x^2+y^2=4$ that forms the boundary of σ in the xy-plane. **(20)**

6. (a) Form partial differential equations by eliminating arbitrary constants a, b, c from $\frac{z^2}{c^2}-\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$. **(12)**

(b) Apply Lagrange method to solve $(x-y)p+(y-x-z)q=z$. **(10)**

(c) Find the integral surface of the first order linear partial differential equation **(13)**

$$2y(z-3)p+(2x-z)q=y(2x-3)$$

which contains $z=0$, $x^2+y^2=2x$.

7. (a) Use Charpit's method to find the complete integral of $z^2=pqxy$. **(12)**

(b) Solve the equation $z=xp+yq+\log(pq)$ by Charpit's method. **(10)**

(c) Solve: $(D_x^2-4D_xD_y+4D_y^2)z=e^{3x+2y}+12xy^2$. **(13)**

8. Solve the following partial differential equations:

(a) $(2D_x^2+D_xD_y-15D_y^2)z=y^2\sin(2x+y)$; **(12)**

(b) $(D_x^2+D_xD_y+D_y-1)z=e^{x+y}\sin(x+y)$;

(c) $(x^2D_x^2-xyD_xD_y-2y^2D_y^2+xD_x-2yD_y)z=x^2y^3$ **(11)**
