SECTION – A
There are EIGHT questions in this section. Answer any SIX.
The questions are of equal value.

1. What is secondary hardening in steel? With necessary diagrams discuss the effects of Mo on the hardenability and mechanical properties of steels.

2. Suggest a suitable tool steel for making cold forming die and with appropriate examples explain your choice. What are the inherent qualities of dual phase carbon-manganese steels?

3. With respect to iron carbon diagram define eutectic reaction. Briefly explain various stages of formation of cementite networks around pearlite grains when the hypereutectoid steel is cooled from sufficiently high temperature to room temperature.

4. Annealing heat treatment significantly improves the corrosion resistance of cold worked austenitic stainless steel — why? A cast steel block has the following chemical compositions:
\[ C = 0.8\%, \text{ Si} = 0.3\%, \text{ Mn} = 1.6\%, \text{ Ni} = 2.0\% \]
\[ \text{Cr} = 8.0\% \text{ and Mo} = 0.6\% \]
Design the heat treatment schedule for full annealing of the steel.

5. What are the benefits of normalizing before hardening of any steel component of critical shape? Schematically show and discuss the austenitization mechanisms of ferritic, pearlitic and spheroidized steels.

6. For proper hardening of high carbon high chromium steels cryogenic treatment is very essential — why? Calculate the Ms temperature and tetragonal distortion of a steel component (1.2% C and 6.0% Cr) when it is quenched from austenitizing temperature.

7. Mention various possible reasons behind the insufficient hardness of a hardened component and discuss with neat sketches.

8. Hardenability concept is very important in predicting hardness of any steel component — explain. After full austenitizing of two identical steel components of same chemical compositions one was quenched in water and the other was quenched in oil. The water and oil quenched components resulted, respectively, 90% and 50% martensite in their microstructures. Calculate the expected hardness values of these two hardened components.

Contd .......... P/2
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SECTION – B

There are EIGHT questions in this section. Answer any SIX.
The figures in the margin indicate full marks.

9. Describe pack carburizing technique with schematic diagram. List some advantages and disadvantages of gas carburizing technique over pack carburizing technique. (17½)

10. Define induction heating process. How much power capacity is required for an induction heater to make hardened the round steel bar work piece of diameter 25 in, 50 mm in length to obtain 1.5 mm hardened depth from the surface in the circumference along 50 mm length by heating 2 seconds? (17½)

11. Briefly discuss the effects of alloying elements in cast irons. What is the compositional requirement to produce gray cast iron? (17½)

12. Describe the annealing practices for nodular cast iron. Differentiate between as cast and annealed nodular cast iron with microstructure. (17½)

13. Explain the heat treatment cycle used for a typical tool steel. What are the purposes of heat treatment of tool steel? (17½)

14. Describe all the transformation steps of tool steel during tampering. How hardness is effected by the tempering temperature? (17½)

15. What is duplex steel? Describe the structure properties relationship for duplex steel. (17½)

16. Precipitation Hardenable (PH) steels offer superior mechanical properties when compared to the martensitic steels of the Fe-Cr-C system. Explain the reason behind such superior properties and the heat treatment process used for PH steels. (17½)
SECTION - A

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

1. (a) Explain the strategic management process. 
   (b) Describe the functions, roles and skills of managers. 
   (c) Describe the factors that are reshaping and redefining the manager's job. 
   (d) Discuss four building blocks of an organization with reference to a steel manufacturing company in Bangladesh.

2. (a) Discuss the characteristics and importance of organizational culture. 
   (b) What is expectancy theory? How will an individual feel motivation according to this theory? 
   (c) Define leader and leadership. Explain Fiedler's contingency model of leadership.

3. (a) Describe different decision-making styles and discuss how biases affect decision making. 
   (b) Mention Henry Fayol's 10 principles of management. Justify your views to apply these principles to a manufacturing firm in Bangladesh. 
   (c) Illustrate different types of organizational structure with appropriate examples and diagrams. 
   (d) How can you distinguish efficiency from effectiveness in management? Give examples to support your answer.

4. (a) Explain what managers do during the six steps of the strategic management process. 
   (b) How can you link Abraham Maslow's need theory to McGregor's theory X and theory Y? 
   (c) How does the Expectancy theory of motivation work in a web development firm? Explain in your own words.
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SECTION – B

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

5. (a) Explain different components of demand. (8)
(b) Briefly describe 'Panel Consensus' method of qualitative forecasting. (7)
(c) Sales for twelve quarters of the year 2015-2017 are given below. Predict sales for each quarter of the year 2018 using linear regression technique. (20)

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Sales</th>
<th>Quarter</th>
<th>Sales</th>
<th>Quarter</th>
<th>Sales</th>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;-2015</td>
<td>540</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;-2016</td>
<td>890</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;-2017</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt;-2016</td>
<td>910</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;-2017</td>
<td>1120</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;-2015</td>
<td>870</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;-2016</td>
<td>1270</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;-2017</td>
<td>1505</td>
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<tr>
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<td>1420</td>
<td>4&lt;sup&gt;th&lt;/sup&gt;-2016</td>
<td>1860</td>
<td>4&lt;sup&gt;th&lt;/sup&gt;-2017</td>
<td>2100</td>
</tr>
</tbody>
</table>

6. (a) Differentiate fixed order and fixed time period inventory models. (8)
(b) Mention the assumptions of basic fixed order quantity model. Define different types of inventory costs. (6+6=12)
(c) Demands of a product for the last seven weeks are as follows: 120, 135, 140, 110, 160, 170, and 135. The source of supply is reliable and maintains a constant lead time of 12 days. The cost of placing an order is $10 and monthly holding costs is $0.12 per unit. Find the economic order quantity and reorder point to satisfy 95% of the demand from the stock on hand. (15)

7. (a) Why project management is very important now-a-days? (10)
(b) Determine the project completion time, critical path and slack time of each non-critical activity for the following information. (25)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Time (weeks)</th>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Time (weeks)</th>
</tr>
</thead>
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<td>J</td>
<td>H,I</td>
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<tr>
<td>B</td>
<td>None</td>
<td>9</td>
<td>K</td>
<td>H,I</td>
<td>2</td>
</tr>
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<td>C</td>
<td>A,B</td>
<td>3</td>
<td>L</td>
<td>H,I</td>
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<td>D</td>
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<td>M</td>
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<td>C</td>
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<td>D</td>
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<td>O</td>
<td>J,L</td>
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<tr>
<td>G</td>
<td>A,B</td>
<td>15</td>
<td>P</td>
<td>M,N</td>
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<tr>
<td>H</td>
<td>E,G</td>
<td>9</td>
<td>Q</td>
<td>N,O</td>
<td>4</td>
</tr>
<tr>
<td>I</td>
<td>F,G</td>
<td>4</td>
<td>R</td>
<td>M,O</td>
<td>6</td>
</tr>
</tbody>
</table>

8. (a) How will you design a feasibility study for a start-up business? (10)
(b) Define Motivation. Compare and contrast contemporary theories of motivation. (10)
(c) Explain how communication can flow most effectively in organizations. (10)
(d) Discuss the investment methods in entrepreneurial ventures. (5)
SECTION – A

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

1. (a) Outline the main features of extrusion process with an aid of a schematic diagram. (13)
   (b) Design and describe an injection molding process suitable for simultaneous PVC
   box production. (22)

2. (a) Differentiate between thermoplastic polymer and thermostet polymer. (14)
   (b) "Localized strengthening is important during tensile loading of a polymer" —
   explain. (5)
   (c) Discuss the factors that influence mechanical properties of polymer. (16)

3. (a) Compare and contrast addition polymerization with condensation polymerization. (16)
   (b) Why impact and fatigue testing are important to polymer? (10)
   (c) The density of two polypropylene materials are 0.904 g/cm$^3$ and 0.895 g/cm$^3$
   respectively, while the associated percent crystallinity of those two materials are 62.8
   and 54.4 respectively. Calculate (i) densities of totally crystalline and totally
   amorphous polypropylene and (ii) density of a specimen having 74.6% crystallinity. (9)

4. (a) Select and outline a manufacturing process suitable for plastic sheet production. (17)
   (b) What is reaction injection molding? Why is reaction injection molding preferred for
   plastic production? (10)
   (c) Mention the roles of filler and stabilizer in enhancing properties of polymer. (8)

SECTION – B

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

5. (a) What is a hybrid composite? (5)
   (b) Why do PMCs enjoy a preeminent position in the field of composites? (15)
   (c) Why is melt stirring not a preferred route for MMCs? (15)
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6. (a) Compare the similarities and dissimilarities of hand and moulding methods. (10)
(b) Draw the sketches for bag moulding methods and explain. (15)
(c) Explain matrix transfer moulding with a sketch. (10)

7. (a) Why a coating is required for CCCs to be used at high temperatures? (5)
(b) Describe chemical vapour deposition of CCCs. (25)
(c) Name a few thermal insulation applications of CCCs. (5)

8. (a) Discuss the stress v/s strain curve for CMCs, PMCs and MMCs. (10)
(b) Explain the processing techniques used for production of dispersion strengthened composites. (18)
(c) What is a cermet? What are the advantages of cermets? (7)
SECTION A

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

1. (a) Schematically show the E vs k diagram of the conduction band and valence band of a semiconductor at \( T = 0 \) K and \( T > 0 \) K in the absence of any external force and prove that the net drift current is zero.

(b) Using the concept of screening explain why the degeneracy of the 2s and 2p orbitals is lifted in all atoms except hydrogen.

(c) Demonstrate that the first derivative of \( E \) with respect to \( k \) is related to the velocity and the second derivative is related to the mass of a free electron. Use these results to explain the concept of effective mass and prove that the effective mass of an electron near the top of the valence band is negative.

2. (a) Consider Fermi-Dirac electronic distribution and calculate the probability of a state with energy \( 0.25 \) eV above the Fermi level to be occupied at \( T = 200 \) K. At what temperature will this probability be doubled?

(b) Derive an expression for the density of states for a 2D infinite square well.

3. (a) Solve the time-independent Schrödinger equation for a 1D infinite potential well and show that energy is quantized in this system.

(b) Consider a 3D infinite potential well with each side \( L = 10 \) nm. Suppose that the 1st and 3rd energy levels are totally empty but the 2nd and 4th levels are totally filled with electrons. All other levels are empty. For this system \( E = \frac{\hbar^2 \pi^2}{2mL^2} (n_x^2 + n_y^2 + n_z^2) \)

where the symbols have their usual meaning.

(i) What are the quantum numbers of the four energy levels mentioned?

(ii) How many electrons are there in each of the filled energy levels?

(iii) If the system is allowed to relax to its lowest possible energy state and if electrons can only drop to the next lowest energy level (i.e. 3 \( \rightarrow \) 2, 2 \( \rightarrow \) 1 etc. is possible 3 \( \rightarrow \) 1 is not possible). What frequencies of light will you detect and what will be their relative intensity?

Contd .......... P/2
4. (a) Analyze a p-n junction showing the band structure before and after the two semiconductors are brought into contact and explain the four different components of current. Demonstrate how rectification is achieved in a p-n junction. (20)

(b) Qualitatively explain why the induced current will become 90 degrees out of phase with the applied electric field when the frequency of light incident upon a conductor becomes so high that \(\omega t >> 1\). In this limit, conductivity can be taken as, \(\sigma = \frac{N\epsilon e^2}{4\pi m}\). Using this, derive the expression for plasma frequency and explain why attenuation of light won't occur when frequency is greater than the plasma frequency for a conductor \(k^2 = \omega^2\mu e + i\omega\mu\sigma\) where all symbols have the usual meaning. (15)

SECTION - B

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

5. (a) Suppose you have to select a copper alloy for the windings of an electromagnet designed to create very high magnetic field. The windings must sustain stresses much higher than pure copper can handle, but alloying copper to increase its strength usually also decrease its conductivity which leads to undesirable increased heating of the windings. To get an increase in strength with minimum decrease in conductivity, should you use soluble or insoluble alloying elements? Justify your answer with proper examples. (8)

(b) In a Hall experiment, a semiconductor carrying current in the positive x-direction is exposed to a magnetic field in the positive y-direction. (Assume a right-handed coordinate system) For different charge carriers (electron and hole) the drift velocity, the cross product of velocity and magnetic field, and the Lorentz magnetic force have different directions. Sketch their directions for different charge carriers and also estimate effective Hall voltage generated due to build up of charges. Moreover, if the longitudinal electric field and the magnetic field are held constant, and the charge carrier concentration of the material were doubled with no change in mobility, by how much would the Hall voltage change? (8)

(c) Because of a shortage of copper during World War II, the electromagnets used in Oak Ridge to separate U-235 isotopes for the Hiroshima atomic bomb were wound with pure silver, which has an atomic volume of 10.3 cc/mol. If 100 m of silver wire 2 mm in diameter required 8.1 watts of electrical power when carrying 4 amps of current, calculate the (i) resistivity, (ii) electron mobility, (iii) collision time, (iv) mean free path, (v) Hall coefficient and (vi) Hall field in a transverse magnetic field of 9 tesla. You may remember that electrical power equals the product of current and voltage. Assume \(T = 300\) K, silver is monovalent (one free electron per atom) and any other missing data. (15)
6. (a) The bound electrons of an atom oscillate under an applied electric field. Determine the amplitude of this oscillation including damping force of electron. (10)

(b) (i) A voltage of 9 volts is applied across an empty capacitor with plates of 10 cm$^2$ area separated by a distance of 3 mm. What is the electric charge on the capacitor plates? (ii) A dielectric with a relative permittivity of 25 is inserted between the capacitor plates. What is now the electric charge on the capacitor plates? What is the charge on the surface of the dielectric? What is the total electric dipole moment per unit volume in the dielectric? (iii) Suppose instead that the 9-volt battery was disconnected from the capacitor before the dielectric was inserted. After insertion of the dielectric, what is the electric charge on the capacitor plates and on the surface of the dielectric? What is the voltage across the capacitor? What is the total electric dipole moment per unit volume in the dielectric? (13)

(c) Mention the processes which attenuate the waves of fiber-optic communication. Discuss these processes with the help of proper equations. (12)

7. (a) Illustrate the magnetic structure of mixed state of Type II semiconductors. Explain how the introduction of microstructural in homogeneities affects the crystal structure and supercurrent of Type II semiconductors. (15)

(b) “A material prefers to be magnetized along an easy axis.” Discuss this statement with the help of anisotropy energy, anisotropy field and domain wall surface. (10)

(c) Cobalt has a saturation magnetization of $1.4 \times 10^6$ A/m and an atomic volume of 6.7 cm$^3$/mole. (i) What is the magnetic dipole moment of each cobalt atom in Bohr magnetrons? (ii) You apply a magnetic field in the easy direction with a coil of 10 turns per meter carrying a current of 3 milliamps and determine that the total field $B$ within the sample is one tesla. Calculate $M$ and determine what percentage of the volume now consists of domain with magnetization parallel of the field. Given that atomic number of Co = 27 and atomic mass of Co = 58.9. (10)

8. (a) Derive the thermal equilibrium concentrations of electrons and holes in a semiconductor as a function of the Fermi energy level. (12)

(b) Discuss the process by which properties of a semiconductor material can be favorably altered by adding specific impurity atoms to the semiconductors. (11)

(c) Determine the ionization energy required to elevate the donor electron into the conduction band using Bohr model of atoms. (12)
SECTION – A

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

1. (a) How does diffraction differ from reflection? Derive the Bragg's equation for diffraction.
   (b) What is reciprocal lattice? Write down the relationship between a reciprocal lattice and its real crystal structure.
   (c) Explain how crystal planes are detected by Ewald sphere method.

2. (a) Explain the scattering of X-ray occurred by an atom and unit cell.
   (b) A high carbon steel (0.84%C) part was quenched and tempered. The microstructure of the sample revealed martensite (α) and austenite (γ). X-ray test was conducted and different diffraction peaks from the planes of martensite and austenite were identified. Calculate the mass fraction of martensite and austenite of the hardened sample. Consider the position of peaks for martensite and austenite are $2θ_{α(211)} = 35.5^\circ$; $2θ_{γ(200)} = 32.2^\circ$ respectively. Peaks intensity found $I_{α(200)} = 69$ unit; $I_{α(211)} = 51$ unit; X-ray radiation was Mo Kα = 0.711 Å.

3. (a) Write down the steps of specimen preparation for carbon replica method for transmission electron microscopic (TEM) investigation. How does image of crystalline solid form in TEM by diffraction contrast mode?
   (b) How will you prepare a ceramic sample for SEM study?
   (c) Discuss the operational variables that are required to obtain good quality SEM image.

4. (a) Why, in your opinion, are people more likely to use an AFM than an STM for topographic examinations? To obtain atomic resolution, the force between the sample and tip of an AFM should decay significantly at a distance of atomic spacing-explain.
   (b) Differentiate between X-ray energy dispersive spectroscopy (EDS) and X-ray wavelength dispersive spectroscopy (WDS) of XRF.
   (c) Suggest and briefly discuss a method to be used in identification and distribution of different reinforcing materials in the matrix of a composite material.

Contd ........... P/2
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SECTION – B
There are FOUR questions in this section. Answer any THREE.
All the symbols have their usual meanings.

5. (a) Discuss the functions of an interferometer in FTIR with suitable diagram.
(b) How can you differentiate the FTIR peaks of O-H bond from N-H bond? Explain with suitable diagrams.
(c) How do you understand by "Conjugate system" for hydrocarbon? Discuss how visible spectroscopy helps us to detect the conjugated hydrocarbon.

6. (a) Differentiate between an Auger electron for AES and an X-ray photoelectron for XPS in terms of calculated kinetic energy.
(b) Explain why calibration is mandatory for XPS peak identification.
(c) The application of a conductive coating to minimize surface charge of an insulating material is an effective method for AES – explain how?

7. (a) Define the general rules for elemental identification for typical SIMS spectrum.
(b) Schematically describe the instrumentation of SIMS.
(c) In SIMS energetic primary ions remove atoms, clusters, fragments from the surface. Elucidate how static SIMS can be considered as nondestructive surface analysis technique.

8. (a) Compare between optical emission spectroscopy (OES) and atomic absorption spectroscopy (AAS).
(b) What do you understand by reversing and non-reversing events in the DSC Curves?
(c) Explain the working principle of temperature modulated differential scanning calorimetry.
(d) Explain how blow holes of a non-ferrous component are identified by a suitable NDT technique.
<table>
<thead>
<tr>
<th>Substance</th>
<th>Type of structure</th>
<th>Lattice parameters (Å)</th>
<th>Spacing of cleavage planes (Å)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe₃C (cementite)</td>
<td>Orthorhombic</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>b = 5.888</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c = 6.740</td>
<td></td>
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<tr>
<td>Austenite</td>
<td>FCC, A1</td>
<td>a = 3.555 + 0.044x (x = weight percent carbon)</td>
<td></td>
</tr>
<tr>
<td>Martensite</td>
<td>BC Tetragonal</td>
<td>a = 2.867 - 0.013x (x = weight percent carbon)</td>
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</table>

Table 1a for Question 2(b)

\[
\begin{array}{cccccccc}
\text{Cubic:} & h & k & l & 4\theta & h & k & l & \text{Spacing} \\
4\theta & 24^\circ & 24^\circ & 12^\circ & 8 & 6 & 2 & 2 \\
\text{Hexagonal and} & h & k & l & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\text{Rhombohedral:} & 24^\circ & 12^\circ & 12^\circ & 6 & 6 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
\text{Tetragonal:} & h & k & l & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
& 10^\circ & 8 & 8 & 8 & 4 & 4 & 2 & 2 & 2 & 2 & 2 & 2 \\
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& 4 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
\end{array}
\]

Table 1b for Question 2(b)

![Graph](image)

Figure 1 for Question 2(b)