Khulna University of Engineering & Technology
B.Sc. Engineering 4th Year 1st Term Examination, 2020
Department of Materials Science and Engineering

MSE 4101
(Modern Iron and Steel Making)

Time: 1.5 hours | Full Marks: 120

N.B. (i) Answer **ANY TWO** questions from each section in separate scripts.
(ii) Figure in the right margin indicates full marks
(iii) Assume reasonable data if any missing

Section A

(Answer **ANY TWO** questions from this section in **answer script A**)

Q 1. (a)

Evolution of blast furnace parameters	Years	
	1960	1990-2000
1. Working height, m	25	25
2. Inner hearth diameter, m	9	15
3. Working volume, m^3	2000	5000
4. Iron production, ton/day	2000	13000
5. Fuel rate, kg/ton hot metal	800	450-500

(30)

i) Why working height remain unchanged for a longer period of time?

ii) Inner hearth diameter has increased with time, why?

iii) Iron production increased from 2000 to 13000 ton per day, how?

iv) Utilization of fuel is observed with time, how?

Q 2. (a) Explain the foaming mechanism of slag. Is slag foaming desirable, how? How can you increase the foaming index of slag? (16)

(b) Mini blast furnace and electro thermal process are two established processes of producing liquid pig iron in small quantities. Out of these two processes which one do you think most suitable for Bangladesh? Justify your answer and explain how liquid iron can be produced by your proposed process. (14)

Q 3. (a) Briefly explain FASTMET process with proper diagram. (15)

(b) What are the metallurgical test performed for physical and chemical characterization of lump ore/ sinter/ pellets? Write a short description how those tests are being performed. (15)

Section B

(Answer **ANY TWO** questions from this section in **answer script B**)

Q 4. (a) How are sulphur and phosphorous removed during the refining period of steel making? (10)

(b) When and how was double slag practice of EAF steelmaking process adopted instead of single slag practice? (10)

(c) Using induction furnace and ladle refining furnace, is it possible to produce good quality steel in Bangladesh? Justify your answer. (10)

Q 5. (a) Explain the thermodynamics of decarburization of chromium melt. (12)

(b) What do you mean by clean steel? 'Synthetic slag practice is principally employed to obtain clean steels and to desulphurise molten steel'-explain. (08)

(c) Calculate values of [H] when molten steel is degassed at 1635k under vacuum. The pressure above the melt is reduced in one case to 1mm Hg and in other cases to 0.1 and 10mm Hg. Steel contains C=0.23%, Cr=8%, Ti=0.4% and Ni=1.5%. (10)

Alloy, i	C	Cr	Ti	Si	Ni
e_H^i	0.045	0.005	-0.22	0.027	0

Q 6. (a) Outline the main steps of stainless steel making process by EAF + AOD route. Which one is better between EAF + AOD and EAF route of stainless steel making? Justify your answer. (12)

(b) With neat sketches show the distribution of pulling in and rejecting forces in a sheet rolling process. Discuss the effects of passive roll gap on these forces and the maximum angle of bite. (10)

(c) A 0.1% C steel strip 50mm wide, 5mm thick was rolled in one pass to 3.5mm at 1060°C when the homogeneous yield stress was 1.05 kN/mm^2. The roll diameter was 340mm. Find the magnitude of the rolling load, taking into account roll flattening, if the rolls were made of cast iron. (08)

Khulna University of Engineering & Technology
B.Sc. Engineering 4th Year 1st Term (Regular) Examination, 2020
Department of Materials Science and Engineering

MSE 4103
(Engineering Alloys and Materials Selection)

Time: 1.5 hours Full Marks: 120

N.B. (i) Answer **ANY TWO** questions from each section in separate scripts.
(ii) Figure in the right margin indicates full marks
(iii) Assume reasonable data if any missing

Section A

(Answer **ANY TWO** questions from this section in **answer script A**)

Q 1. (a) What are the carbide phases present in stainless steel? What role do these phases play regarding the mechanical properties of stainless steel? (12)

(b) Why is high-strength low-alloy steel termed as high-purity steel? How is this alloy an ideal choice for making automobile body? (10)

(c) How does maraging steel attain high tensile strength? (08)

Q 2. (a) "Tool steels should be at least double-tempered" Discuss this statement giving emphasis on the mechanism of tempering in tool steels. (12)

(b) What outstanding properties do Aluminium-Silicon alloys have? Give some typical applications. (10)

(c) Why are most copper-zinc alloys not age-hardenable? (08)

Q 3. (a) Which of the nickel-based alloys would you recommend for rocket engine? How does this alloy attain properties suitable for aforementioned application? (10)

(b) How does Cu-Al-Ni alloy system recover previously defined shapes after being subjected to thermomechanical cycle? (12)

(c) What are the functions of grain refiners and modifiers in aluminium alloys? (08)

Section B

(Answer **ANY TWO** questions from this section in **answer script B**)

Q 4. (a) Derive the expression for the gain in bending stiffness when a solid square beam of side b_o is expanded at constant mass to a larger square section with a prismatic cell structure. (15)

(b) The following figure. 4(b) shows a concept for a lightweight display stand. The stalk must support a mass of 100kg, to be placed on its upper surface at a height h, without failing by elastic buckling. It is to be made of stock tubing and must be as light as possible (15)

(i) Derive a material index for the tubular material of the stand that meets these requirements and that includes the shape of the section, described by the shape factor $\phi_B^e = \frac{12I}{A^2}$, where I is the second moment of area and A is the section area.

(ii) Cylindrical tubing is available from stock in the following materials and sizes. Use this information and the following material index table to identify the best stock material for the column of the stand. Given that the shape factor of thin walled tube is $\phi_B^e = \frac{3r}{\pi t}$

Table 1: for Q4. (b) (ii)

Material	E, GP_a	$\rho, kg/m^3$	R, mm	t/r ratio
Aluminium alloys	71	2700	25	0.07-0.25
Steel	210	7900	30	0.045-0.10
Copper alloys	120	8900	20	0.075-0.10
Polycarbonate	3	1200	20	0.15-0.30
Various wood	8-16	500-800	40	Solid circular section only

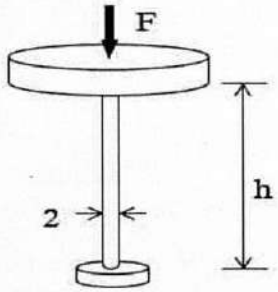

Figure: 4(b)

Q 5. (a) How material, function, shape and process are interrelated? Explain with suitable examples. (10)

(b) Draw the design flow chart. (05)

(c) Using helmet visor as example, discuss the strategy for materials selection. (15)

Q 6. (a) What are the approaches that simultaneously maximizes both materials index and shape factor. Briefly explain the approaches with necessary diagrams. (15)

(b) A connecting rod is a critical component in a high-performance engine, compressor or pump. If it fails, catastrophe follows. Yet to minimize inertial forces and bearing loads, it must weigh as little as possible, implying the use of light, strong materials, stressed near their limits. When minimizing cost is the objectives, con-rods are frequently made of cast iron because it is so cheap. But what are the best materials for con-rods when the objectives is to maximize performance? Let the specifications are $L = 200\ mm$, $F = 50\ kN$, $\alpha = 0.8$, $\beta = 1.5$ in figure 6(b). Given that Euler buckling load is $F = \frac{\pi^2 EI}{L^2}$ and $I = \frac{b^3 w}{12}$ (15)

Table 2: for Q6. (b)

Material	$\rho, kg/m^3$	E, GP_a	σ_e, MP_a
Nodular cast iron	7150	178	250
HSLA steel 4140	7850	210	590
Al 5355.0	2700	70	95
Al-SiC(P) Composite	2880	110	230
Titanium 6Al 4V	4400	115	530

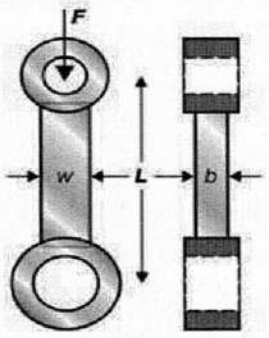

Figure: 6(b)

Khulna University of Engineering & Technology
B.Sc. Engineering 4th Year 1st Term Examination, 2020
Department of Materials Science and Engineering

MSE 4105
(Polymer and Composite Materials)

Time: 1.5 hours Full Marks: 120

N.B. (i) Answer **ANY TWO** questions from each section in separate scripts.
(ii) Figure in the right margin indicates full marks
(iii) Assume reasonable data if any missing

Section A

(Answer **ANY TWO** questions from this section in **answer script A**)

Q 1. (a) Briefly explain the terms: (09)
(i) Degree of polymerization
(ii) Polydispersity
(iii) Kinetic chain length.

(b) Deduce the Kinetics of free radical polymerization and derive the relation between R_p, $[I]$ and $[M]$. (13)

(c) "Glass transition temperature is important during in service life of polymer". Explain. (08)

Q 2. (a) Discuss a manufacturing process suitable for plastic bottle production with neat sketch. (10)

(b) "Localized strengthening is important during tensile loading of a polymer". Explain (10)

(c) A nylon 6.6 sample with a moisture content (MC) of 2.5 % has an elastic modulus of 1.2 GN/m^2, while that for a sample of moisture content of 0.4 % is 2.1 GN/m^2. Calculate the elastic energy or work per unit volume in each sample subjected to a tensile strain of 25%. (10)

Q 3. (a) What is copolymerization? Discuss the synthesis process and properties of linear (Polyethylene oxide-block-Polystyrene) block co-polymer. (15)

(b) What do you mean by layer by layer deposition technique? Discuss the polymer capsule (hollow spherical polymeric shell) formation by LBL technique with necessary figure. (15)

Section B

(Answer **ANY TWO** questions from this section in **answer script B**)

Q 4. (a) Why composite materials are developed? Briefly explain the functions of matrix and fiber in composite materials. (10)

(b) Illustrate the factors that affecting the properties of composite materials. (08)

(c) What is work of adhesion? Show that work of adhesion is equal to twice of surface energy of liquid-vapor. (12)

Q 5. (a) Write a short note on nanocomposite and hybride composite (08)

(b) Show that, modulus of composite, $E_c = E_f V_f + E_m(1 - V_f)$ (10)

(c) Write down following composite fabrication methods with advantages and disadvantages. (12)
(i) Pultrusion
(ii) Compression molding

Q 6. (a) Derive the Young's equation for wetting. (10)

(b) What is coupling agent? Write down the roles of coupling agent in composite materials with applications and necessary figures. (10)

(c) Calculate the longitudinal modulus and tensile strength of a unidirectional composite containing 60 % by volume of sisal fibers in epoxy matrix. The modulus and strength of fiber is 40 GPa and 500 MPa, respectively and the same for matrix is 3.5 GPa and 100 MPa respectively. Find the fraction of load taken by matrix and fiber in the composite. (10)

Khulna University of Engineering & Technology
B.Sc. Engineering 4th Year 1st Term Examination, 2020
Department of Materials Science and Engineering

MSE 4107
(Computational Materials Science)

Time: 1.5 hours | Full Marks: 120

N.B. (i) Answer **ANY TWO** questions from each section in separate scripts.
(ii) Figure in the right margin indicates full marks

Section A

(Answer **ANY TWO** questions from this section in **answer script A**)

Q 1. (a) Define computational materials science and engineering? Describe the goals of computer simulations. (10)

(b) How computer simulations data supports the experimental results? Explain with example. (10)

(c) Write down three methods and applications for each of nano-micro, micro-meso and meso-macro levels in materials simulations. (10)

Q 2. (a) What is density functional theory? What are the properties that can be calculated by density functional theory? (12)

(b) Describe Born-Oppenheimer approximation. (08)

(c) What is Rietveld refinement? How materials scientist benefits from the Rietveld refinement process? Explain. (10)

Q 3. (a) Proof that, the external potential is a unique functional of the density. (08)

(b) Write down self-consistent procedure to solve Kohn-Sham equations with flow charts and explanations. (12)

(c) Correlate the experimental results with simulated data using flow chart with proper explanations. (10)

Section B

(Answer **ANY TWO** questions from this section in **answer script B**)

Q 4. (a) How does molecular dynamics simulation work? Explain with a flowchart. (12)

(b) How can you set a specific temperature in molecular dynamics simulation in the microcanonical ensemble? Explain briefly. (12)

(c) What is the difference between NVE and NVT? (06)

Q 5. (a) How does Verlet algorithm work? Also, mention its advantages and disadvantages. (15)

(b) Consider a one-dimensional harmonic oscillator of mass, m, that follows Hooke's law, $F = -kx$, in an isolated system (E=const). Then Newton's second law becomes the second-order ordinary differential equation, (15)

$$a(t) = -\frac{k}{m}x(\mathrm{t})$$

Let us assume that the spring is fixed at one side and is an ideal spring with zero mass and spring constant k. Given the oscillation frequency of $\omega = \sqrt{\frac{k}{m}} = 2$ and initial conditions $x_o = 4.5$ and $v_o = 0$, find the following:

(i) Write down the potential expression for the system.

(ii) Numerical solution for ball positions with time by taking the first two terms in the Taylor series expansions (the Euler methods) with $\Delta t = 0.2$ for 5 timesteps.

Q 6. (a) What is Ising model? How do you simulate the Ising model with the Metropolis algorithm? (15)

(b) How does time average different from ensemble average? (08)

(c) How does the weighting function provide a critical link between thermodynamics variable and probability in Monte Carlo Method? (07)

Khulna University of Engineering & Technology
B.Sc. Engineering 4th Year 1st Term Examination, 2020
Department of Materials Science and Engineering

MSE 4109
(Electronic, Magnetic and Optical Properties of Materials)

Time: 1.5 hours Full Marks: 120

N.B. (i) Answer **ANY TWO** questions from each section in separate scripts.
(ii) Figure in the right margin indicates full marks
(iii) Assume reasonable data if any missing

Section A

(Answer **ANY TWO** questions from this section in **answer script A**)

Q 1. (a) Define relaxation time for a free electron. "A materials engineer interested in controlling electrical conductivity should usually focus on controlling charge carrier density if working with nonmetals and on controlling mobility if working with metals"-Explain (10)

(b) According to Debay's model "Heating a cup of tea in microwave oven is due to orientation polarization"-Explain. (12)

(c) The electronic polarizability of argon gas is 1.74×10^{-40} farad.m^2. Calculate the dielectric susceptibility and dielectric constant of argon gas under standard temperature and pressure. (Assume an insert gas, which has 2.69×10^{25} molecules per m^3 at standard temperature and pressure) (08)

Q 2. (a) What is normalized eigen function? In case of a step potential function as shown in Figure 2(a), when $E<V_0$, "there is a non zero probability of finding the particle in the region $x>0$, where classically, the particle has no chance of ever reaching"-Explain. (20)

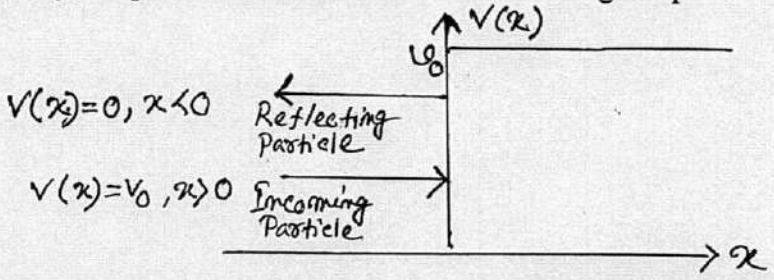

fig. 2(a)

(b) For a free electron, calculate the density of quantum states per unit volume (cm^3) over the energy range of (i) $0 \le E \le 2$ eV and (ii) $1 \le E \le 2$ eV (10)

Q 3. (a) Derive an expression for density of states. (15)

(b) "Polyacetylene is considered to be the prototype of a conducting polymer"-explain. (07)

(c) Determine the relative effective mass (m/m_0) of conduction band electron within a crystal lattice having a lattice parameter a =10 Å. Assume that the electronic state of the conduction band follows a parabolic E vs K relationship; where at $K = \pm\pi/a$, $E = E_c + 0.32$ eV and at $K = 0$, $E = E_c$. Given that: $m_0 = 9.11 \times 10^{-31}$ Kg; $\hbar = 1.054 \times 10^{-34}$ J-s; 1eV = 1.6×10^{-9} J. (08)

Section B

(Answer **ANY TWO** questions from this section in **answer script B**)

Q 4. (a) Define magnetic anisotropy? Explain magnetic anisotropy for BCC single crystal of Fe. (10)

(b) What is magnetic moment? Describe origins of magnetic moment with necessary figures. (10)

(c) How information is stored in magnetic storage device? Explain with necessary figures. (10)

Q 5. (a) What is magnetic hysteresis loop? Explain the magnetization and demagnetization processes of hysteresis curve. (14)

(b) Write a short note on Anti-ferromagnetism and Ferrimagnetism. (10)

(c) Describe the photoconductivity phenomenon? (06)

Q 6. (a) What is electromagnetic radiation? Write the properties and applications of X-ray, ultra-violet and Gamma rays. (10)

(b) Define magnetic permeability (μ_r) and susceptibility (χ_m). Give the relation between magnetic susceptibility and relative permeability. (10)

(c) What is absorption process? Describe the absorption of light by inter-band and intra-band transitions. (10)