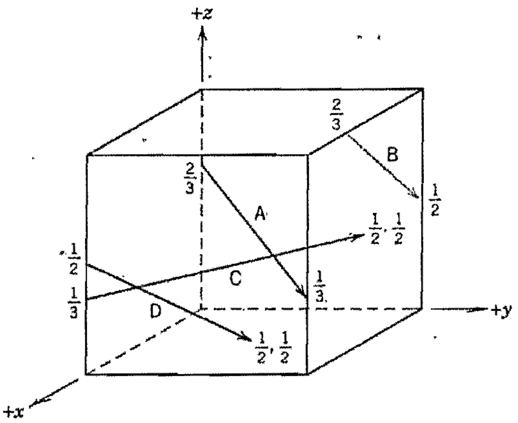
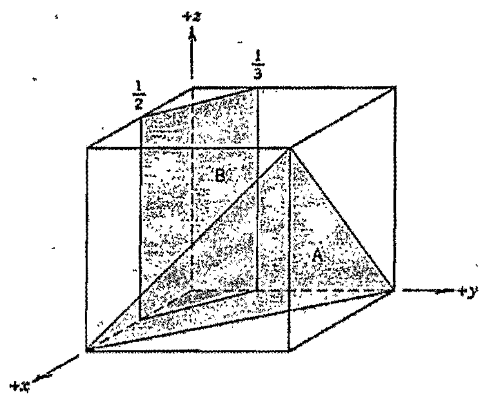
國立雲林科技大學
99學年度碩士班暨碩士在職專班招生考試試題
系所：化材系
科目：材料科學導論(1)

1. Determine the indices for the directions shown in the following cubic unit cell: (20%)



2. Determine the Miller indices for the planes shown in the following unit cell: (10%)



3. Molybdenum has a BCC crystal structure, an atomic radius of 0.1363nm, and an atomic weight of 95.94 g/mol. Compute its theoretical density. (10%)

4. For a steel alloy it has been determined that a carburizing heat treatment of 12 h duration will raise the carbon concentration to 0.45 wt% at a point 3 mm from the surface. Estimate the time necessary to achieve the same concentration at a 6 mm position for an identical steel and at the same carburizing temperature. (10%)

5. A strip of chicken skin was excised for mechanical testing in tension. The initial dimensions of the rectangular specimen were 30 mm long and 15 mm wide, with an average thickness of 3 mm. The mechanical testing was conducted at a rate of 5 mm/sec. The following data were obtained:

Gauge length (mm)	Force (N)
20.0	0.0
20.5	0.1
21.0	0.3
21.5	0.5
22.0	0.8
22.5	1.1
23.1	1.6
23.6	2.0
24.2	2.7
24.6	3.6
25.2	4.7
25.7	6.2
26.3	7.9
26.8	9.7
27.4	11.4
27.9	12.9
28.5	14.5
29.0	16.4
29.6	18.3
30.1	19.6

(a) Calculate the engineering stresses and strains from the information given and plot the engineering stress-strain curve. Assume that 5 mm of the specimen length is clamped by the testing grips at each end, such that the initial gauge length of the specimen is 20 mm. (10%)

(b) It was found that immediately before the last data point, the average width of the sample was 8 mm and the average thickness of the sample was 0.75 mm. Considering this information, determine the true stress and true strain of the sample at the last data point. (10%)

(c) Compare the true stress and strain values for the final data point with the engineering stress and strain values for the final data point (5%)

6. Calculate the density of a poly(ethylene) sample that is 75% crystalline, knowing that the density of completely amorphous poly(ethylene) is 0.85 g/cm^3 and the density of completely crystalline poly(ethylene) is 1.00 g/cm^3. (5%)

7. Consider the following polymer size fractions of a given polymer sample:

Fraction	Molecular weight	Number of Chains
1	5000	1000
2	10000	1000
3	1000000	3

(a) Calculate the number-average molecular weight of the polymer. (5%)
(b) Calculate the weight-average molecular weight of the polymer. (5%)
(c) Which average molecular weight determination did the 3 chains of molecular weight 1000000 most significantly affect? Why? (5%)
(d) Calculate the polydispersity index of the polymer. (5%)

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1. (16 points)

One mole of gas in a closed system undergoes a four- step thermodynamic cycle. Use the data given in the following table to determine numerical values for the missing quantities, i.e., "fill in the blanks." (作答時請複製本表，並在打?格內填上答案)

Step	ΔU^t/J	Q/J	W/J
12	-500	?	-6,000
23	?	-3,800	?
34	?	-1200	300
41	5,4 00	?	?
12341	?	?	-1,900

2. (14 points)

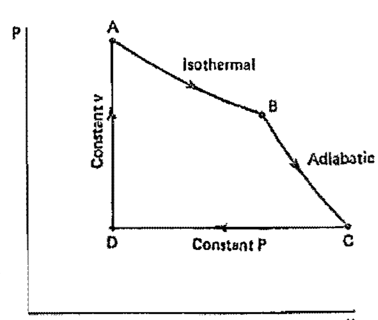
A particular power plant operates with a heat-source reservoir at 350 ℃ and a heat-sink reservoir at 30 ℃. It has a thermal efficiency equal to 55% of the Carnot-engine thermal efficiency for the same temperature.

(a) What is the thermal efficiency of the plant?

(b) To what temperature must the heat-source reservoir be raised to increase the thermal efficiency of the plant to 35%? Again η is 55% of the Carnot-engine value.

3. (20 points)

One kmol of an ideal gas is taken through a four-step cyclic process as displayed on the PV diagram shown below. The gas is subjected successively to an isothermal expansion at 600 K from 5 to 4 bar(A to B), an adiabatic expansion to 3 bar(B to C), a constant pressure cooling(C to D), and constant-volume heating(D to A). All processes are assumed reversible. For these processes it is reasonable to assume C_p is constant and equal to 30 kJ/kmol · K. Calculate Q, W, Δu, and Δh for each step and for the entire process.



4. (15 points)

A liquid mixture of species 1 and 2 for which the mole fraction of species 1 is 0.6 is in equilibrium with its vapor at 144 °C. Determine the equilibrium pressure and vapor composition. The system forms an azeotrope at 144 °C for which the species 1 composition is 0.294. At 144 °C, the saturation vapor pressures of species 1 and 2 are 75 kPa and 32 kPa, respectively. The correlation of activity coefficient (γ) and liquid composition (x) is given below.

■ $\ln\gamma_1 = Ax_2^2,\ \ln\gamma_2 = Ax_1^2$

5. (15 points)

Mixtures of CO and CO_2 are to be processed at temperatures between 900 and 1000 K and 1 atm. Determine under what conditions solid carbon (C) might deposit according to the reaction $CO_2(g) + C(c) \leftrightarrow 2CO(g)$. For this reaction, the equilibrium constants are 0.178 at 900 K and 1.58 at 1000 K.

6. (20 points)

A copper block having a mass of 10 kg and at a temperature of 527 °C is placed in a well-insulated vessel containing 100 kg of water initially at 17 °C. Calculate the entropy changes for the block, the water and the total process. The heat capacities are 4.185 kJ/kg-K for water and 0.398 kJ/kg-K for copper.

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本試題兩頁共 6 題，合計 100 分。請依題號作答，並將演算過程及答案寫在答案卷上，違者不予計分。

1. (15%) Consider a feed $C_{Ao} = 100$, $C_{Bo} = 300$, $C_{Io} = 100$ to a steady-state CSTR. The isothermal gas-phase reaction is $A + 2B \longrightarrow 4R$ (I: inerts).
If $C_A = 50$ at the reactor exit, what is C_B, X_A, and X_B there?

2. (20%) A rapid, first-order liquid reaction is carried out in a fixed-volume, well-mixed flow reactor under isothermal conditions. Let τ and T_s be the space time and the time necessary to reach 99% of the steady-state concentration, respectively. Please derive the following relation: $T_s = \dfrac{4.6}{k}$ where k is the specific reaction rate.

3. (15%) A reaction $A \rightarrow B$ was carried out in a well-mixed reactor and the following data were recorded:

Conversion, X	0	0.2	0.4	0.5	0.6	0.8	0.9
$-r_A$ (mol/dm^3-min)	10	16.67	50	50	50	12.5	9.09

The entering molar flow rate of A was 300 mol/min. What is the well-mixed reactor volume necessary to achieve 40% conversion?

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4. Please explain the following terms：

（a） space time （5%）

（b） packed bed catalytic reactor （5%）

（c） multiple reactors （5%）

5. A dilute aqueous of A is to be hydrolyzed continuously at 27℃ . At this temperature the rate equation for the disappearance of A is $r = 0.2C_A$ g mole/（cm^3）（min） where C_A is concentration of A , The feed rate to be treated is 600 cm^3/min ,with a A concentration of 2×10^{-4} g mole / cm^3 . There are two 3-liter and a 6-liter reaction vessels available , with excellent agitation devices .

（a） Would the conversion be greater if the one 6-liter vessel were used as a steady-flow tank reactor or if the two 3-liter vessel were used as reactors in series ？In the latter case all the feed would be sent to the first reactor and the product that would be the feed to the second reactor .（8%）

（b） Would the conversion be increased if a tank-flow reactor of 3-liter were followed with a 3-liter tubular-flow reactor？（7%）

6. A solid-catalyzed gaseous reaction has the form $A + B \rightarrow C$

Sketch curves of the initial rate vs. the total pressure for the following cases:

（a） The mechanism is the reaction between adsorbed A and adsorbed B molecules on the catalyst. The controlling step is the surface reaction.（10%）

（b） The mechanism is the reaction between adsorbed A and B in the gas phases. The controlling step is the surface reaction.（10%）

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1. The standard enthalpy of a certain reaction is approximately constant at +188 kJ mol^{-1} from 800 K up to 1500 K. The standard reaction Gibbs energy is +27.5 kJ mol^{-1} at 1200 K. Estimate the temperature at which the equilibrium constant becomes 1. (15%)

2. The following consecutive reactions are elementary.

$$A \xrightarrow{k_a} I \xrightarrow{k_b} P$$

If the initial concentration of A is $[A]_0$, and no I & P are present initially. Find the rate of formation of P by using the steady-state approximation. (20%)

3. Deduce an expression for the time it takes for the concentration of a substance (A) to fall to one-third its initial value ($[A]_0$) in an nth-order reaction with a rate constant (k). (15%)

4. One mole of an ideal monatomic gas expands isothermally from 1 bar, 0.025 m^3, and 300 K into an evaluated container. The final volume is 0.050 m^3. Calculate q and w and each of the thermodynamic quantities ΔU, ΔH, ΔG, ΔA, and ΔS for the process. (12%)

5. The enthalpy of fusion of mercury is $2.29\,\text{kJ mol}^{-1}$, and its normal freezing point is 234.3 K with a change in molar volume of $+0.52\,\text{cm}^3\,\text{mol}^{-1}$ on melting. At what temperature will the bottom of a column of mercury (density $13.6\,\text{g cm}^{-3}$) of height 20.0 m expected to freeze? (14%)

6. Consider a solution containing 20 g of hemoglobin in 1 liter of the solution is placed in the right compartment, and pure water is placed in the left compartment. At equilibrium, the height of the water in the right column is 77.8 mm in excess of the height of the solution in the left column. What is the molar mass of hemoglobin? The temperature of the system is constant at 298K. (12%)

7. It is found that the boiling point of a binary solution of A and B with $x_A = 0.4217$ is 96 ℃. At this temperature the vapour pressure of pure A and B are 110.1 kPa and 94.93 kPa, respectively. (a) Is this solution ideal? (b) What is the initial composition of the vapour above the solution? (12%)

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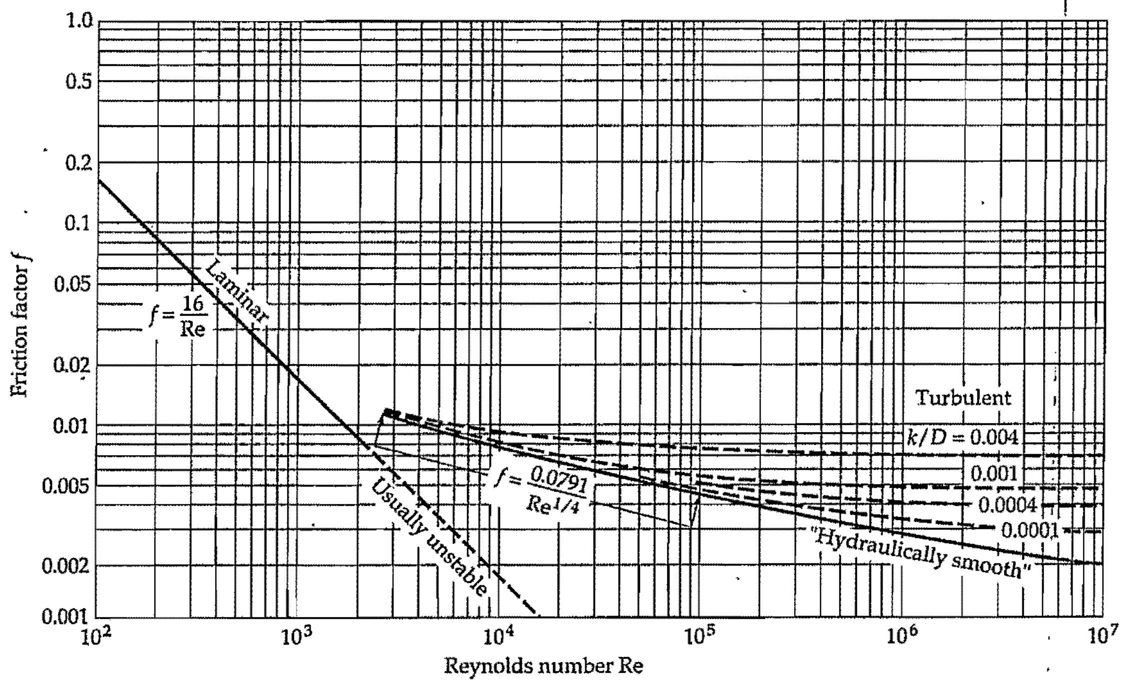
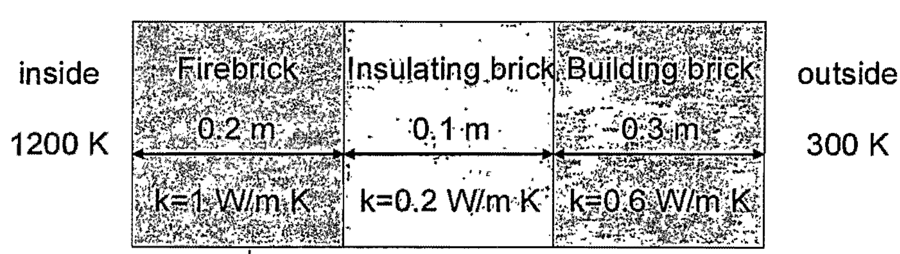
1. A liquid is flowing through a horizontal straight pipe at 5 m/s. The diameter D and roughness k of the pipe are 25 cm and 0.025cm, respectively. The viscosity of the liquid is 2 cp and its density is 800 kg/m^3.
   (a) Calculate the Reynolds number. (5%)
   (b) Find the friction factor from the following figure. (5%)
   (c) Find the pressure drop for a 40 m section of pipe. (5%)



2. A furnace is constructed with 0.2 m of firebrick, 0.1 m of insulating brick, and 0.3 m of building brick. The inside temperature is 1200 K and the outside temperature 300 K. The thermal conductivities are as shown in the following figure. Assuming the heat transfer is one-dimensional and steady-state, find
   (a) the heat loss per unit area, and (10%)
   (b) the temperature at the junction of the fire brick and the insulating brick. (5%)



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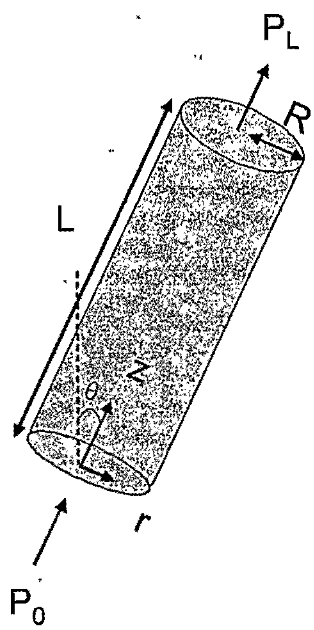
3. A laminar Newtonian fluid flows through a circular tube with radius R as the following figure. The edge effects are unimportant. Make a differential shell momentum balance to find the momentum flux distribution τ. (20%)



4. Predict the thermal conductivity (k) of helium (M=4) at 50℃ and 4 atm. At 25℃ and 1 atm the viscosity is 1.94×10^{-4} g/cm-sec. The Lennard-Jonse parameter ε/k is equal to 10.2 K. The Chapman-Enskog equations are: (10%)

$$\mu = 2.67\times10^{-5}\frac{\sqrt{MT}}{\sigma^2\Omega_\mu}$$ where T [=] K, σ[=] Å, μ[=] g/cm-sec

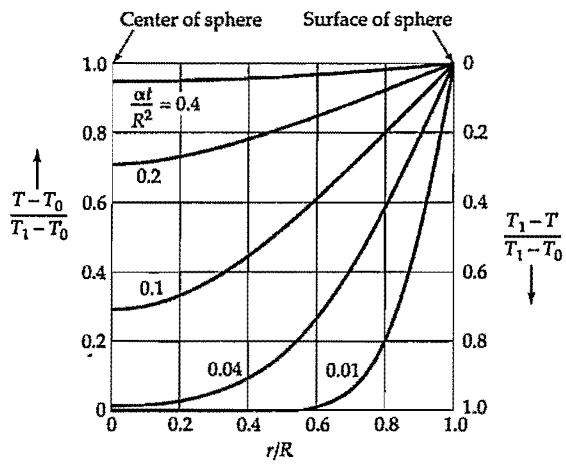
$$k = 1.99\times10^{-4}\frac{\sqrt{T/M}}{\sigma^2\Omega_k}$$ where k[=] cal/cm-sec-K

The collision parameters, Ω, are given in the attached table.

kT/ε	$\Omega_\mu = \Omega_k$	Ω_D	kT/ε	$\Omega_\mu = \Omega_k$	Ω_D
1.00	1.593	1.440	20.0	0.7436	0.6640
2.00	1.176	1.075	25.0	0.7198	0.6414
3.00	1.0388	0.950	30.0	0.7010	0.6235
5.00	0.9268	0.8428	35.0	0.6854	0.6088
10.0	0.8244	0.7422	40.0	0.6723	0.5964

5. A spherical water drop is suspended from a fine thread in still, dry air. Show that the Sherwood number for mass transfer from the surface of the drop into the surroundings has a value of 2 if the characteristic length is the diameter of the drop. (10%)

6. An iron sphere of 1-in. diameter has the following properties: $k = 30$ Btu/hr-ft-°F, $C_p = 0.12$ Btu/lb_m-°F, and $\rho = 436$ lb_m/ft^3. Initially the sphere is at a temperature of 70 °F.
   (a) What is the thermal diffusivity of the sphere? (5%)
   (b) If the sphere is suddenly plunged into a large body of fluid of temperature 270 °F, how much time is needed for the center of the sphere to attain a temperature of 128 °F? (5%)
   (c) A sphere of the same size and same initial temperature, but made of another material, requires twice as long for its center to reach 128°F. What is its thermal diffusivity? (5%)



7. The cooling effect of evaporation from a wetted surface can be used to analyze certain simple gas mixtures. Consider, for example, the arrangement in the following Fig, in which a mixture of condensable gas A and noncondensable gas B flows over a pair of long cylindrical thermometers. One thermometer bulb (the dry bulb) is left bare, and the other (the wet bulb) is covered with a wick saturated with liquid A. Fresh liquid A at the wet-bulb temperature continuously flows up the wick by capillary action from the reservoir below. Develop an equation for the composition of the gas stream in terms of the wet-bulb and dry-bulb thermometer readings. For simplicity, it is assumed that the fluid velocity is high enough that the thermometer readings are unaffected by radiation and by heat conduction along the thermometer stems. The viscous dissipation heating effects is also neglected. (15%)