1. The stress rate of shear for a non-Newtonian fluid is given by

\[ \tau_{\text{sr}} = K \left( -\frac{dv_r}{dr} \right)^n \]

where \( K \) and \( n \) are constants. Find the relation between velocity and radial position \( r \) for this incompressible fluid at steady state. [Hint: Combine the equation given here with

\[ \tau_{\text{sr}} = \left( \frac{p_0 - p_L}{2L} \right) r \]

Then raise both sides of the resulting equation to the \( \frac{1}{n} \) power and integrate.] (25%)

2. A fluidized coal reactor has been proposed for a new power plant. If operated at 1145K, the process will be limited by the diffusion of oxygen countercurrent to the carbon dioxide, CO₂, formed at the particle surface. Assume that the coal is pure solid carbon with a density of 1.28x10^3 kg/m³ and that the particle is spherical with an initial diameter of 1.5x10^-4 m (150μm). Air (21%O₂ and 79%N₂) exists several diameters away from the sphere. Under the conditions of the combustion process, the diffusivity of oxygen in the gas mixture at 1145K is 1.3x10^-4 m²/s. If steady-state process is assumed, calculate the time necessary to reduce the diameter of the carbon particle to 5x10^-5 m (50μm). (25%)

3. An electric wire having a diameter of 1.5 mm and covered with a plastic insulation (thickness = 2.5 mm) is exposed to air at 300 K and \( h_o = 20 \) W/m²·K. The insulation has a \( k \) of 0.4 W/m·K. It is assumed that the wire surface temperature is constant at 400 K and is not affected by the covering. (25%)

(a) Derive and calculate the value of the critical radius.
(b) Calculate the heat loss per meter of wire length with no insulation.
(c) Repeat (b) for insulation being present.

4. The Fourier field equation in cylindrical coordinates is

\[ \frac{\partial T}{\partial t} = \alpha \left( \frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} + \frac{1}{r^2} \frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2} \right) \]

(25%)

(a) What form does this equation reduce to for the case of steady-state, radial heat transfer?
(b) Given the boundary conditions \( T = T_o \) at \( r = r_i \)

\[ T = T_i, \text{ at } r = r_o \]

Solve the resulting equation from part (a) for the temperature profile.
(c) Generate an expression for the heat flow rate, \( q_r \), using the result from part (b).
1. Wet steam containing 2% by weight of entrained liquid (98% quality) at 5 bar is available at the rate of 1 kg/s. It is desired to mix this wet steam at 5 bar and 200°C to obtain dry saturated steam at 5 bar. The mixing will be considered adiabatic. At what rate should the superheated steam be added? H (5 bar sat. liquid) = 640.23 kJ/kg, H (5 bar sat. vapor) = 2748.7 kJ/kg, H (5 bar, 200°C superheated vapor) = 2855.4 kJ/kg (10%) 

2. Find the equation for the work of a reversible, isothermal compression of 1 mol of gas in a piston/cylinder assembly if the molar volume of the gas is given by \( P = \frac{RT}{V - b} - \frac{a}{V^2} \) Here, a, b and R are positive constants. (12%) 

3. Calculate the heat required to raise the temperature of 1 mol of methane from 500 K to 900 K in a steady-flow process at a pressure sufficiently low that methane may be considered an ideal gas. The molar heat capacity of methane in the ideal-gas state is given as a function of temperature in kelvins by: \( \frac{C_p}{R} = 1.702 + 9.081 \times 10^{-3}T - 2.164 \times 10^{-6}T^2 \) (12%) 

4. A rigid vessel of 0.08 m³ volume contains an ideal gas, \( C_V = (5/2)R \), at 550 K and 2 bar. If heat in the amount of 20 kJ is transferred to the gas, determine its entropy change. (16%) 

5. A system consists of a sample of ethanol with a heat capacity of 238.6 J K⁻¹. Calculate the change in the entropy of the system when its cools from 50.0 °C to 20.0 °C. (10%) 

6. The standard enthalpy of formation of NO₂ (g) is 33.1 kJ mol⁻¹. Given that \( 2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) \) \( \Delta H^\circ = -114.6 \text{ kJ mol}^{-1} \) Calculate the standard enthalpy of formation of NO (g). (10%) 

7. (a) Write down the phase rule. (5%) 
(b) Use the phase rule to predict the degree of freedom for the system of liquid water in equilibrium with a mixture of water vapor and nitrogen. (5%) 
(c) What variable(s) is (are) required to specify the state of the system? (5%) 

8. The adiabatic throttling process if often called a Joule-Thomson expansion. The process is characterized by constant enthalpy and can be visualized as an isenthalp \( (\partial T / \partial P)_H \) in a T-P diagram. Please show the Joule-Thomson coefficient. (15%) 

\[
\left( \frac{\partial T}{\partial P} \right)_H = \frac{1}{c_p} \left[ T \left( \frac{\partial V}{\partial T} \right)_p - V \right]
\]
1. Please give an example to explain the following terms: (15 %)
   (a) Zwitterion of amino acid
   (b) Quaternary structure of protein
   (c) Integral proteins
   (d) Lipid bilayer
   (e) Denaturation of DNA

2. Shown below is the enzyme-catalyzed reaction proposed by Michaelis and Menten:

   \[ E + S \overset{k_1}{\underset{k_2}{\rightleftharpoons}} ES \overset{k_3}{\underset{k_4}{\rightleftharpoons}} E + P \]

   (a) Please derive the Michaelis - Menten equation shown below using adequate assumptions (7 %)
   \[ v = \frac{V_{\text{max}} [S]}{K_M + [S]} \]

   (b) Derive the Lineweaver-Burk equation and plot to show the parameters of \( K_M \) and \( V_{\text{max}} \) (8 %)

3. Please give an example with experimental method to explain the semiconservative replication of DNA? (10 %)

4. What is the relationship in terms of base sequence between the RNA transcript and the DNA coding strand? Please give an example to explain! (10 %)

5. 下列五種化合物: amino acid、tripeptide、hexapeptide、insulin、oxytocin 使用 gel filtration chromatography 分離時,試依逆洗順序排列,由先至後。(10%)

6. 試列出維繫蛋白質一級、二級、三級及四級結構之鍵結方式? (10%)

7. 下列二種單醣化合物(A, B)中,(a)列出具有對掌中心之C號碼,(b)寫出是D式或L式?(10%)

8. 寫出下列化合物之結構式:(10%)
   (a)L-alanine, (b)L-glycine, (c)L-valine, (d)D-glucose, (e)D-fructose

9. 寫出下列物質經水解過程之產物?(10%)
   (a)澱粉, (b)蔗糖, (c)肝醣, (d)乳糖, (e)果糖
1. Solve $e^y(1+x^3)dy - 3x^2dx = 0$ (15%)

2. $(y^2 + 1)dx + (2xy + 4)dy = 0$ is an exact ODE? Try to solve it. (10%)

3. Solve: $y'' - 5y' + 6y = 6x, \ y(0) = \frac{5}{6}, \ y'(0) = 2$ (15%)

4. Solve $\frac{\partial^2 u}{\partial x \partial y} = 3$, if $u(0, y) = \cos y$, $u(1, y) = \frac{3}{2} + \sin y + \cos y$, find $u(x, y) = ?$ (10%)

5. Please use the method of separation of variables to solve $\frac{\partial u}{\partial t} - \frac{\partial u}{\partial x} = 0, \ x > 0, \ t > 0$, if $u(0,t) = 6e^{-t}$, find $u(x,t) = ?$ (10%)

6. Find the Laplace Transformation of $f(t) = \begin{cases} t & 0 \leq t \leq 4 \\ 3e^{2t} & 4 \leq t \end{cases}$ (15%)

7. Find the inverse Laplace transform: $F(s) = \frac{1}{s(s+1)}$ (10%)

8. Apply Laplace transform to solve the initial value problem $y'' - 3y' + 2y = e^y, \ y(0) = 0, \ y'(0) = 0$ (15%)
1. A copper bottle contains 20 L of high-pressure nitrogen, its pressure is 10 atm, temperature is 25°C. Calculate the work done by the gas at constant temperature and volume. (6%)

2. A 180.1 g ice block at -10°C is added to 20°C water, and the final temperature is 10°C. The specific heat capacity of ice is 0.49 cal/°C-g, and the specific heat capacity of water is 1.0 cal/°C-g. The heat of fusion for ice is 100 cal/g. (10%)

3. What is the total kinetic energy of translation in ergs of 2 moles of perfect gas at 27°C? In calories? (6%)

4. We know \( dU = T \, dS - p \, dV \) and define \( H = U + PV \). (12%)

\[
\begin{align*}
A &= U - TS \\
G &= H - TS,
\end{align*}
\]

Please derive the equations \( dH = T \, dS + V \, dp \) and \( dA = -S \, dT - p \, dV \) and \( dG = -S \, dT + V \, dp \).

5. One example of a first-order reaction is the isomerization of hydrogen isocyanide to hydrogen cyanide:

\[
\text{HNC (g)} \quad \longrightarrow \quad \text{HCN (g)}
\]

If the rate constant at a particular temperature is \( 4.403 \times 10^{-4} \, \text{s}^{-1} \), what mass of HNC remains after 1.50 hr if a 1.00 gram sample of HNC was present at the beginning of the reaction? (10%)

6. What is the total kinetic energy of translation in ergs of 2 moles of perfect gas at 27°C? In calories? (6%)

7. Explain the meanings of the following glossaries: (10%)

(1) closed system  (2) spontaneous process  (3) the first law of thermodynamics

8. A piston filled with 0.05 mole of an ideal gas expands reversibly from 50 mL to 400 mL at a constant temperature of 27°C. Calculate q, W, \( \Delta U \), \( \Delta H \), \( \Delta S \), and \( \Delta G \) for the process. (15%)

9. Determine \( \Delta H_{\text{fus}} \) for the following reaction at 500 K and constant pressure:

\[
2A(g) + B(g) \rightarrow 3C(g) + 2D(g)
\]

The following data are necessary:

<table>
<thead>
<tr>
<th>Substance</th>
<th>( C_p )</th>
<th>( \Delta H^\circ(298 , \text{K}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>29</td>
<td>-110</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>-241</td>
</tr>
<tr>
<td>C</td>
<td>37</td>
<td>-393</td>
</tr>
<tr>
<td>D</td>
<td>25</td>
<td>-265</td>
</tr>
</tbody>
</table>

Where the units for \( C_p \) are J/mol·K and the units for heat of formation (\( \Delta H^\circ \)) are kJ/mol. Assume molar quantities. (15%)

10. Consider the chemical reaction

\[
A + B + C \rightarrow \text{products}
\]
Determine the order with respect to A, B, and C, and construct the complete rate law (including the value of the rate law constant) from the following experimental data. (10 %)

<table>
<thead>
<tr>
<th>Initial rate (M/s)</th>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.76 x 10^{-6}</td>
<td>0.550</td>
<td>0.20</td>
<td>1.15</td>
</tr>
<tr>
<td>9.82 x 10^{-7}</td>
<td>0.210</td>
<td>0.20</td>
<td>1.15</td>
</tr>
<tr>
<td>1.68 x 10^{-6}</td>
<td>0.210</td>
<td>0.333</td>
<td>1.15</td>
</tr>
<tr>
<td>9.84 x 10^{-7}</td>
<td>0.210</td>
<td>0.20</td>
<td>1.77</td>
</tr>
</tbody>
</table>
1. (a) Write a balanced acid-base reaction that produces Na₂S (5 %)
(b) If Na₂S is added to an aqueous solution of H₂S (Kₐ = 9.1 x 10⁻⁸), will the pH of the solution rise or fall? Explain. (8 %)

2. A glass containing 360 ml of a soft drink (a carbonated beverage) was left sitting out on a kitchen counter. If the CO₂ released at room temperature (25°C) and pressure (1 atm) occupies 1.50 L, at a minimum, what is the concentration (in ppm) of the CO₂ in the original soft drink (assume the density of the original soft drink is 0.970 g/mL and the ideal gas constant (R) = 0.08206 L atm / mol K). (12 %)

3. The percent composition of compound Z is 63.16% C and 8.77% H. When compound Z burns in air, the only products are carbon dioxide and water. The molar mass for Z is 114.
(a) What is the molecular formula for compound Z? (6 %)
(b) What is the balanced reaction for Z burning in air? (6 %)

4. C₆H₁₂O₆ → 2 C₂H₅OH + 2 CO₂ (g)
(a) If 25.0 g of C₆H₁₂O₆ were used, and only 10.2 g of C₂H₅OH were produced, how much reactant was left over and what volume of gas was produced? (Note: one mole of gas occupies 24.0 L of space at room temperature.) (7 %)
(b) What was the percent (%) yield of the reaction? (3 %)
(c) What type of reaction took place? (3 %)

5. Given that 4.50 moles of NH₃ occupy 5.20 L at 47°C, calculate the pressure of the gas in atm using (a) the ideal gas equation (4 %) and (b) the van der Waals equation

\[
\frac{P}{nRT} = \frac{V - nb}{aV^2} \quad \text{for NH}_3, \quad \text{van der Waals equation} \quad (P + \frac{an^2}{V^2})(V - nb) = nRT \quad (6 %)
\]

6. Given the thermochemical equation

\[
\text{SO}_2(g) + 0.5 \text{O}_2(g) \rightarrow \text{SO}_3(g) \quad \Delta H = -99.1 \text{ kJ/mole}
\]
Calculate the heat evolved when 96 g of SO₂ is converted to SO₃? (S=32 O=16) (8 %)

7. Gold (Au=197 g/mol) crystallizes in a cubic close-packed structure (the face centered cubic unit cell) and has a density of 19.3 g/cm³. Calculate the atomic radius of gold in nm. (15 %)

8. Iodine atoms combine to form molecular iodine in the gas phase

\[ \text{I}(g) + \text{I}(g) \rightarrow \text{I}_2(g) \]
The reaction follows second order kinetic and has the high rate constant 7.0 x 10⁹/M•s at 23°C.
(a) If the initial concentration of I was 0.086 M, Calculate the concentration after 60 seconds (12 %), (b) Calculate the half life of the reaction if the initial concentration of I is 2.0 M (5 %)