1. Solve the nonhomogeneous differential equation (10%)

$$y'' - 2y' + y = e^x + x$$

2. Solve the nonhomogeneous differential equation (10%)

$$y'' + y = \sec x$$

3. Solve the system (10%)

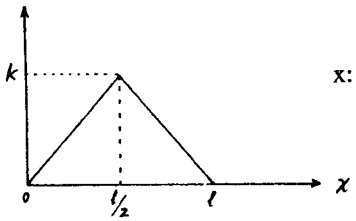
$$\begin{aligned} 2x_1 - x_2 + 2x_3 &= 2 \\ x_1 + 10x_2 - 3x_3 &= 5 \\ -x_1 + x_2 + x_3 &= -3 \end{aligned}$$

4. Find the Fourier Series of the following function (10%)

$$f(x) = x^4 \quad (-\pi < x < \pi), \qquad f(x+\pi) = f(x)$$

5. Show that $\frac{1}{2^2} + \frac{1}{6^2} + \frac{1}{10^2} + \cdots = \frac{\pi^2}{32}$. (15%)

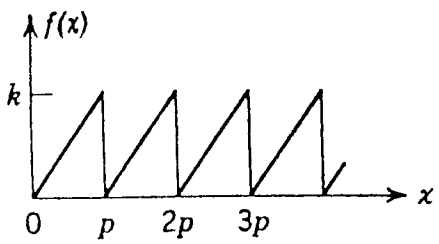
Hint:



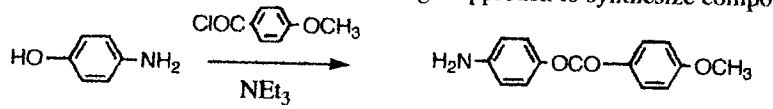
x: variable, k and l: constants

6. Find the Laplace transform of the function (10%)

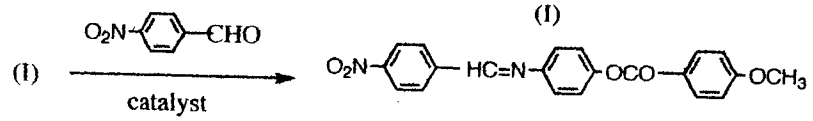
$$f(x) = \frac{k}{p}x \quad (\text{when } 0 < x < p), \qquad f(x+p) = f(x)$$



1) a) The following procedures is not a right approach to synthesize compound (II). Why? (10 %)



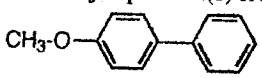
(I)

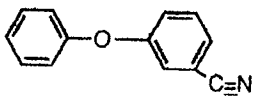


(II)

b) Suggest another reasonable approach to synthesize (II). (10 %)

2) a) Predict the major product(s) from the mononitration of: (may have more than one product)

(i) 

(5 %) (ii) 

(5 %)

b) Give an explanation for the above result (10 %).

3) Asign structures to each of the following, given the NMR spectra as shown:

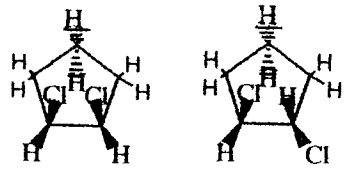
a) $C_5H_{10}O_2$ δ) 3.5 singlet; 1.2 singlet; 9.7 singlet (5 %)

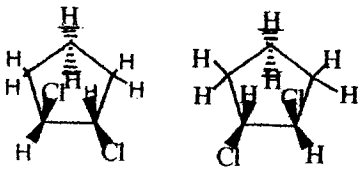
b) C_2Cl_3HO δ) 9.1 singlet (5 %)

c) $Br_4C_5H_8$ δ) 3.6 singlet (5 %)

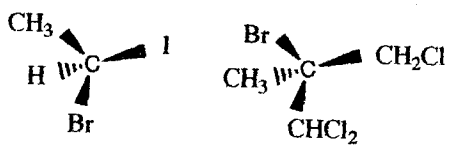
d) $C_{12}H_{18}$ δ) 2.2 singlet (5 %)

4) a) Classify the following pairs of cyclopentane derivatives as structural isomers, diastereomers or enantiomers (10 %)

i) 

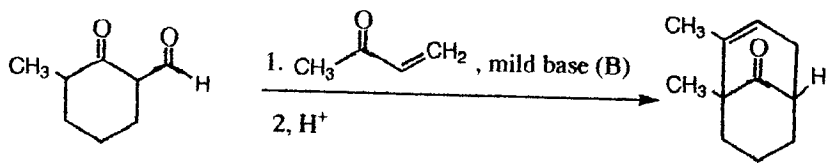
ii) 

b) Assign R and S configurations to the two structures given below (10 %)



5) Given a mechanism for each of the following reactions:

a) $CH_3COCl + H_2C{=}C(OCH_3)_2 \longrightarrow CH_3CCH_2CCH_3$ (10 %)

b) 

(10 %)

國立中山大學八十六學年度碩士班招生考試試題

科　目：物理化學(材料科學研究所)　甲組

1. Derive and define the unit (SI system of units only, others not acceptable) of the following physical properties from the original law, statement, principle, etc. Take , for example, the SI unit for the force F is "N" (Newton), and it is defined in the famous Newton's second law of motion, F = ma, where m is the mass and a is the acceleration. Please remember to define all the symbols you use. [40%, 5%/each]

   a) entropy, S
   b) viscosity, η
   c) surface tension, σ
   d) diffusion coefficient, D
   e) refractive index, n
   f) absorbance, A (used in the spectroscopic measurements)
   g) chemical potential, μ
   h) thermal conductivity, k

2. Physical sputtering deposition process has been a very important and popular technique for the preparation of metal oxide or organic "thin film", with thickness down to sub-micrometer. These types of thin films are used in numerous electronic and electro-optic devices. The sputtering is a process whereby a target material (same as the thin film material) is bombarded by high-energy ions which liberate atomic or molecular species from the target for deposition to form a thin film onto a substrate.

   a) State the energy requirement for this type of bombardment and explain why. [10%]
   b) In general, when an energy beam passes through a vacuum to the surface of certain materials, it interacts with the atoms and molecules of the material. In terms of photochemistry and spectroscopy, list all the possible consequences of the various interactions. [10%]

3. Liquid crystals (LCs) are materials that attract much research attentions in recent decades. It has been reported that both small molecules and polymers can exist in the LC state; yet, special chemical structures are required.

   a) Describe the physical picture about the LCs in the liquid phase and state why. [10%]
   b) Describe the requirement of the chemical structures for LCs for both small molecules and polymers and state why. [10%]

4. In regions with mild winters, heat pumps can be used for space heating in winter and cooling in summer. Assuming ideal thermodynamic efficiency for the pump, compare the cost of keeping a room at 25 °C in winter and in summer when outside temperatures are 12 and 38 °C, respectively. What assumptions did you make in this calculation? Suppose the heat pump was running 50 % of the time when the outside temperature was 12 °C. If the outside temperature fell to 0 °C, could this heat pump maintain the inside at 25 °C? [20%]

國立中山大學 八十六 學年度碩博士班招生考試試題

科 目：材料力學 乙組（材科所）

* You must choose 5 out of 6 questions. *

1. In a known stress field, only σ_{xy}, σ_{yz} exist, where $\sigma_{xy}=\tau\cos\theta$, $\sigma_{yz}=\tau\sin\theta$. Please find principal stress. (20%)

2. If Von Mises theory is the yield criteria, and a material has tensile yield stress $\sigma_0=100$ksi, please find the σ_x to the yield when $\sigma_x=\sigma_y$ and $\sigma_z=0$. (20%)

3. The strain energy $E=1/2(\sigma_{ij}\varepsilon_{ij})$. Please expand it in terms of principal stress when it is under plane stress condition. (20%)

4. Calculate the total elongation δ of a square bar of length ℓ and cross-sectional area A which hangs vertically under its own weight. Assume that γ is the density of this material. (20%)

5. A thin circ lar steel plate of radius r and thickness t is subjected to inward radial stress σ uniformly distributed around its circumference. Determine the state of stress on any element inside the plate and also the unit volume change of the entire plate. (20%)

6. In a body we find $\sigma_{xx}=50$ksi, $\sigma_{yy}=30$ksi, $\tau_{xy}=20$ksi, please find $\sigma_{x'x'}+\sigma_{y'y'}$, when x rotates 30 degree to the new axis.x', and y to y'. (20%)

國立中山大學八十六 學年度碩博士班招生考試試題

科 目：熱力學（材料所） 丙組

1. 10 Kg of water (C_p = 1 cal/g °C) at 20 °C is mixed with 2 Kg of ice (C_p = 0.5 cal/g °C) at –5 °C. The latent heat of ice is 80 cal/g.
   (a) What is the final temperature?
   (b) What is the entropy change of the system? (20%)

2. (a) Start from basic definitions, derive the equation $C_p = C_V + [P + (\partial U/\partial V)_T](\partial V/\partial T)_P$.
   (b) For an ideal gas, is C_p always larger than C_V? Explain it with the first law of thermodynamics. (20%)

3. (a) Derive the equation $[\partial(G/T)/\partial(1/T)]_P = H$.
   (b) For a reaction with a free energy change of ΔG, explain how can you obtain the entropy change ΔS, the volume change ΔV and the enthalpy change ΔH of the reaction. (25%)

4. For an ideal gas performing a Carnot cycle
   (a) Draw the PV and TS diagrams. Explain each part of the diagrams with the corresponding equation. Indicate on the diagrams which parts of the cycle involve heat flow into and out of the gas, and the net work done.
   (b) Draw the corresponding TV and TP diagrams.
   (c) Derive the efficiency directly from the TS diagram. (20%)

5. Two identical bodies of constant heat capacity at temperatures T_1 and T_2, respectively, are used as reservoirs for a heat engine. Both bodies remain at constant pressure and undergo no change of phase. If T_f is the final temperature attained by both bodies,
   (a) what is the amount of work obtainable?
   (b) What is the final temperature T_f when work is a maximum. (15%)