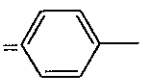
國立中山大學九十學年度碩博士班招生考試試題

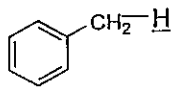
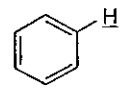
科目：有機化學【材料所碩士班】甲組

1) In each of the following sets, arrange the nucleophiles in order of increasing reactivity and explain it.
a) $CH_3CH_2NH_2$, CH_3CH_2OH, CH_3CH_2SNa toward propyl bromide. (10 %)
b) Ph-OH, $CH_3CH_2CH_2$-CH_2OH toward CH_3CH_2-$COOCH_3$ (10 %)

P.S. Ph = 

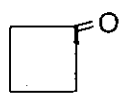
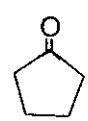
2) Rank the following compounds in order of the ease with which the hydrogen underlined can be abstracted by a free-radcial process? (10 %) Explain it. (10 %)

a) $CH_3CH_2CH_2CH_2\underline{CH_2}$ (H) b) $CH_3\underline{C}(=O)-H$ c) $CH_3\underline{CH}(H)CH_3$

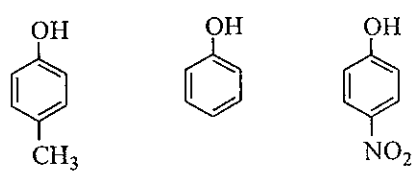
d)  e) 

3) a) Depict the two possible chair-form conformations of cis-1,3-dimethylcyclohexane. (4 %)
b) Which one of the above conformations is more stable? (2 %) Why? (4 %)

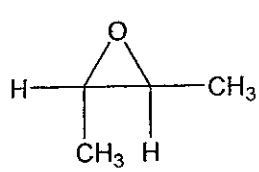
4) In the following sets, compound A always has higher carbonyl stretiching band than compound B. Explainit.
a) $CH_3CH_2CH_2COCH_3$ (A) $CH_3CH{=}CHCOCH_3$ (B) (7 %)

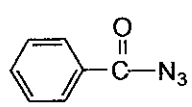
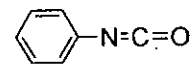
b)  A  B (8 %)

5) Rank the following compounds in each sets in order of the acidity and explain it.
a) $CH_3CH_2CH_2CO_2H$ $CH_3CH_2\underline{CH}(Cl)CO_2H$ (7 %)

b)  (8 %)

6) Write down the mechanistic steps for the following transformations.

a)  $\xrightarrow[\text{b) } H_2O,\ H^+]{\text{a) } Et_2NLi,\ Et_2O}$ $CH_3CH(OH)$-$CH{=}CH_2$ (10 %)

b)  $\xrightarrow{\Delta}$  (10 %)

國立中山大學九十學年度碩博士班招生考試試題

科目：物理化學【材料所碩士班】甲組

1. Explain the followining terms.
   (1) Einstein-de Broglie postulate. [5%]
   (2) Born-Oppenheimer approximation. [5%]
   (3) Frank-Condon principle. [5%]
   (4) Stokes and anti-Stokes shifts. [10%]

2. In vibrational spectroscopy,
   (1) What is the physical meaning of 'normal modes'? [5%]
   (2) Show that there are generally 3N-6 normal modes of vibration for a molecule composed of N atoms but only 3N-5 normal modes in the special case of linear molecules. [5%]
   (3) Absorption bands are often referred to as IR-active or Raman-active. What factors determine the 'activity' of a normal mode towards IR or Raman spectroscopy. [10%]

3. In UV-Vis spectra, there often exists an isosbestic point at which the absorbance is invariant with respect to changes in the temperature or composition of the sample studied. What can be the physical origin of this isosbectic point? [10%]

4. Using an energy diagram, explain the differences between fluorescence and phosphorescence. What are the typical time scales involved in the two processes? [15%]

5. Assuming the presence of a metastable transition-state $(AB)^*$, derive a rate expression for the idealized reaction $A + B \Leftrightarrow (AB)^* \rightarrow C$. Compare this rate expression with the empirical 'Arrhenius law' $k = k_o \exp(-E_a/RT)$ and comment on physical meanings of the activation energy E_a and the pre-exponential factor k_o. [15%]

6. (1) Are there similarities between the ideal gas and the ideal solution in terms of the equations of state? What is the physical meaning of this similarity? [10%]
   (2) Extending the analogy into the slightly non-ideal cases, what is the physical meaning of the second virial coefficient A_2 in the virial expansion (i.e., $\pi/cRT = 1/M + A_2c + \ldots$ where π is the osmotic pressure, c the solute concentration, and M the molecular mass of the solute)? [5%]

國立中山大學九十學年度碩博士班招生考試試題

科目：工程數學【材料所碩士班】乙組

1. (a) A radioactive material decomposes at a rate proportional to the amount present. Suppose that the proportional constant is $k = -1.5 \times 10^{-11}$ sec^{-1} for the radioactive substance contained in the nuclear waste of our nuclear power plants. How many years will it take for this substance to decompose to 1/2 of its original quantity? (10%)
   (b) The occurrence of serious earthquake of grade ≧ 7 in Taiwan is once every 50 years on average. If the probability of leakage of radioactive material caused by a serious earthquake is 1/10, calculate the probability of no leakage throughout the period calculated in (a). (10%)
2. Solve the following initial value problems:
   (a) $y''+6y'+9y=0$, $y(0)=-4$, $y'(0)=14$. (10%)
   (b) $\ddot{y}+2\dot{y}+2y=3.5\sin 3t-3\cos 3t$. $y(0)=0$, $\dot{y}(0)=-0.5$. (10%)
3. (a) Find the directional derivative $\frac{\partial f}{\partial s}$ of $f(x,y,z)=2x^2+y^2+3z^2$ at the point (1, 1, 1) in the direction of vector $\vec{i}+\vec{j}+\vec{k}$. (10%)
   (b) f(x,y, z) and $\vec{v}$ (x, y, z) are scalar and vector functions, respectively. Given sufficient differentiability, show that curl $(f\vec{v})=\nabla f \times \vec{v} + f \cdot \text{curl}(\vec{v})$. (10%)
4. (a) $\int_C yzdx + xzdy + xydz = ?$ C: the intersection of $x^2+y^2=1$ and $z=1$. (10%)
   (b) $\int_{(1,0,1)}^{(0,1,1)} yzdx+xzdy+xydz=?$ (10%)
5. (a) transform $x=3.303303303303\ldots$ into a quotient (i.e. a real number divided by another real number). (8%)
   (b) for any complex z, $z^2 = |z|^2$, true or false? Why? (6%)
   (c) for any complex z and its conjugate z*, $|z|^2 = z \cdot z^*$, true or false? Why? (6%)

國立中山大學九十學年度碩博士班招生考試試題

科目：材料力學【材料所碩士班】乙組

材料科學研究所碩士班入學考試材料力學考題

下列每題二十分

1. When σ_x is employed in a cube, $E = \sigma/\varepsilon$, $\nu = -\varepsilon_y/\varepsilon_x$, please demonstrate that $\Delta V/V = \varepsilon_x(1-2\nu)$ and illustrate the limit of ν, where V is the volume of the cube. (hint: $\ell_1 = \ell(1+\varepsilon)$, $V = A\ell$)

2. σ_{ij} exist everywhere in a plane(x, y). Please calculate the principal stresses and the angle to the x-axis.

3. A mild steel with Young's modulus $E = 30 \times 10^3$ ksi, yield stress $\sigma_{yp} = 40$ ksi, proportional stress $\sigma_{p\ell} = 30$ ksi is in pin-ended condition. Please calculate and draw the save critical stresses with respect to slenderness ratio for which buckling will not occur.

4. Constancy of the volume is true for a deformed material. Please calculate the stress and strain when a load P is applied.(hint: considering $A\ell = A_1\ell_1$)

5. Please calculate the required diameter d on the basis of an allowable working σ_w in tension, while a bending couple M in the x-y plane and a twisting couple T about the x-axis are applied on a circular bar.

國立中山大學九十學年度碩博士班招生考試試題

科目：工程數學【材料所碩士班】丙組

Please note that (1) *a calculator can be used for this test*, (2) *partial credits will be given* ***only*** *to incomplete answer relevant to the solution of the problem*, and (3) *the test has five problems.*

1. (***Linear Algebra***) (15 pts.) In Cartesian coordinate system, any point in space can be identified using mutually orthogonal unit vectors $\hat{x}$, $\hat{y}$ and $\hat{z}$. If this coordinate system undergoes a rotational transformation to $\hat{x}'$, $\hat{y}'$ and $\hat{z}'$ with

$$\hat{x}' = \frac{1}{\sqrt{3}}\hat{x} + \frac{1}{\sqrt{3}}\hat{y} - \frac{1}{\sqrt{3}}\hat{z},$$

$$\hat{z}' = \frac{1}{\sqrt{2}}\hat{x} - \frac{1}{\sqrt{2}}\hat{y},$$

please find $\hat{y}'$.

2. (***Integration***) (15 pts.) Find the volume of a tetrahedron (四面體) bounded by coordinate surfaces ($x = 0, y = 0, z = 0$) and the plane $x + \frac{y}{2} + \frac{z}{3} = 1$.

3. (***Fourier Series***) (20 pts.) Use the Fourier series of $f(x) = x$ in the range $-\pi < x \leq \pi$ to show that

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots\cdots = \frac{\pi}{4}$$

4. (***Differential Equation***) (25 pts.) Solve for $y(x)$ from $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = x^2 \sin 2x$.

5. (***Statistics***) (25 pts.) An important relationship of probability theory is called the Stirling's formula which states that as n becomes large ($n >> 1$), $n(n-1)(n-2)\cdots(1) \equiv n!$ can be approximated as

$$n! \approx n\log n - n$$

Please prove the Stirling's formula.

國立中山大學九十學年度碩博士班招生考試試題

科目：熱力學【材料所碩士班】丙組

1. A thermally insulated cylinder closed at both ends is fitted with a frictionless heat-conducting piston which divides the cylinder into two parts. Initially the piston is clamped in the center with 1 liter of air at 300 °K and 2 atm pressure at one side and 1 liter of air at 300 °K and 1 atm pressure on the other side. The piston is released and reaches equilibrium in pressure and temperature at a new position. Compute the final pressure and temperature and the total increase of entropy. R = 8.314 J/mole °K = 0.082 l-atm/mole °K (20%)

2. Show that for an ideal gas performing a reversible process, dQ is not a perfect differential but dQ/T is. (15%)

3. Can a close system of an ideal gas be subjected to an *isothermal*, *isentropic* and *reversible* process? Explain. (15%)

4. Two identical bodies of constant heat capacity C_P are at the same initial temperature T_1. A refrigerator operates between these two bodies until one body is cooled to temperature T_2. If the bodies remain at constant pressure and undergo no change of phase,
   (a) calculate the final temperature of the second body.
   (b) Show that the minimum amount of work needed to do this is
   $$W_{min} = C_P (T_2 - 2T_1 + T_1^2 / T_2).$$ (25%)

5. From the first and second TdS equations,

   $$TdS = C_P\, dT - T (\partial V/\partial T)_P\, dP$$
   $$TdS = C_V\, dT + T (\partial P/\partial T)_V\, dV$$

   (a) derive the equation $C_P - C_V = -T (\partial V/\partial T)_P^2 (\partial P/\partial V)_T$. (15%)
   (b) Explain why C_P can not be less than C_V ? (5%)
   (c) When will C_P be equal to C_V ? Explain with an example. (5%)