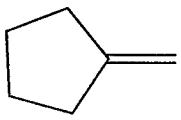
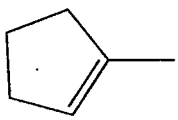
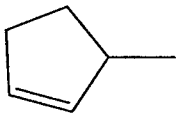
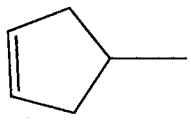
國立中山大學101學年度碩士暨碩士專班招生考試試題

科目：有機化學【材光系碩士班甲組】

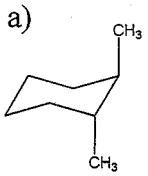
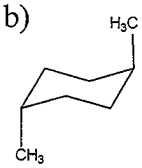
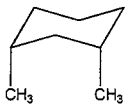
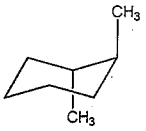
題號：4102

1. **選擇題** (單選, Each 2%, Total: 30%)

1) ( ) Which compound does not give two isomers when reacted with Cl_2/CCl_4?

a)  b)  c)  d) 

2) ( ) Which of the diaxial compounds has the highest energy (unstable)?

a)  b)  c)  d) 

3) ( ) What is the role of diethyl ether in the following reaction?

$$CH_3CH_2OCH_2CH_3 + BF_3 \rightleftharpoons (CH_3CH_2)_2\overset{\oplus}{O}\,\overset{\ominus}{BF_3}$$

a) Lewis acid, b) Lewis base, c) Brønsted acid, d) Brønsted base

4) ( ) Which molecules contain both covalent and ionic bonds?

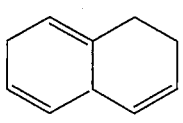
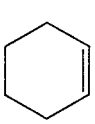
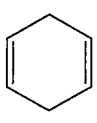
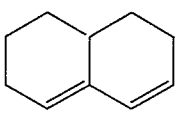
(I) CH_3OH, (II) Na_2CO_3, (III) NH_4Cl, (IV) NaCl

a) I, II; b) II, IV; c) I, II, IV; d) II, III

5) ( ) Which of the statements below correctly describes an achiral molecules? a) The molecule has a non-superimposable mirror image. b) The molecule exhibits optical activity when it interacts with plane-polarized light. c) The molecule has an enantiomer. d) The molecule might be a meso form. e) none of the above.

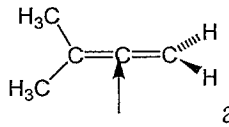
6) ( ) When an organic molecule is irradiated with ultraviolet radiation, the energy absorbs by the molecule corresponds to a) the amounts of energy to increase molecular motions in functional groups, b) the amounts of energy to excite electrons from one molecular orbital to another, c) the amounts of energy to "flip" the spin of atomic nuclei, d) the amounts of energy to strip a molecule of one electron to generate one radical cation.

7) ( ) Which of the following compounds would show the longest wavelength in its UV spectrum?

(a)  (b)  (c)  (d) 

8) ( ) Which of the following additions to alkene occur(s) specifically in a syn fashion? a) dihydoxylation using OsO_4, b) addition of H_2. c) addition of HCl, d) both a and b, e) none of the above.

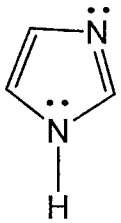
9) ( ) Choose the correct hybridization for the atom indicated in the molecule below:



a) sp, b) sp^2, c) sp^3, d) none of the above.

10) ( ) Treatment of cyclopentene with *m*-chloroperoxybenzoic acid (MCPBA): a) results in oxidative cleavage of the ring to produce an acyclic compound. b) yields a meso epoxide. c) yields an equimolar mixture of enantiomeric epoxides. d) none of the above.

11) ( ) How many π-orbital electrons are in the following molecule? a) 4; b) 6; c) 8; d) 10.



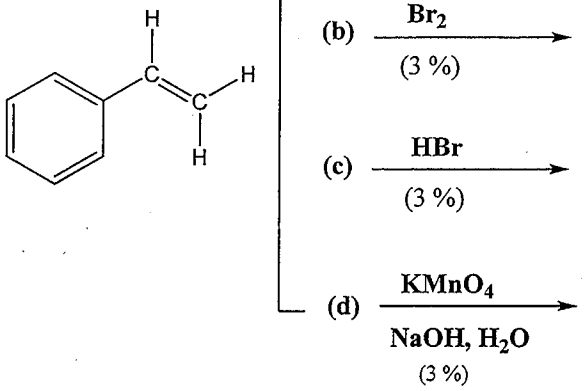
12) ( ) A meso compound is a) an achiral molecule that contains chirality centers. b) contains a plane of symmetry or a center of symmetry. c) is optically inactive. d) is characterized by all of above.

13) ( ) Which statements apply to an S_N1 reaction? a) I, II; b) III, IV; c) I, IV; d) III, I. (see the statements I, II, III and IV shown below)
I) The rate limiting step of the reaction involves the alkyl halide and the nucleophile; II) The order of reactivity is methyl > 1°>2°>3°; III) The rate limiting step of the reaction involves the alkyl halide; IV) There is an intermediate carbocation.

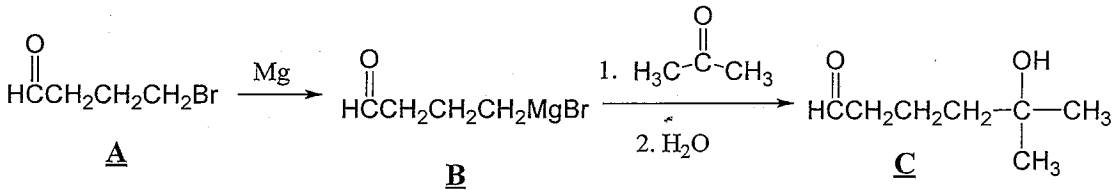
14) ( ) How many isomers, including stereoisomers, can be formed from the hydroxylation of 4-methylcyclohexene using osmium tetroxide (OsO_4)? a) 2; b) 4; c) 6; d) 8.

15) ( ) Which of the following additions to alkene occur(s) specifically in a anti fashion? a) addition of Br_2, b) Addition of H_2, c) Addition of H_2O in dilute solution, d) Both a and b, e) none of the above.

2. (Each 3%, Total: 12 %) Predict the products of the following reactions. Also, indicate regioselectivity (*syn* or *anti*-addition) where relevant. (Suppose that the aromatic ring is inert to all the indicated reagents.)



3. (Total: 18 %) As one of the most frequently-used reagents in organic chemistry, Grignard reagents are commonly prepared from the reaction of alkyl halides with magnesium metal. Reaction scheme shown below also follows the same way by reacting alkyl bromide A with magnesium metal to generate the desired Grignard reagent B. The reagent B was then served as nucleophile to attack acetone to yield the final product C:



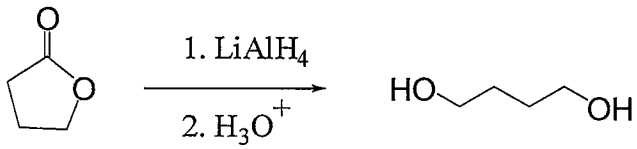
A B C

1) However, product C actually can not be obtained from the above reaction pathway. What is the problem in the above reaction pathway? (6 %)

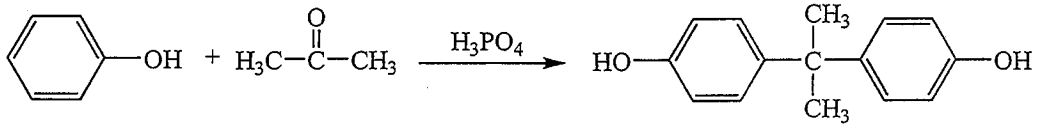
2) Write alternative reaction pathway for the successful preparation of compound C. (12 %)

4. (Each 8%, Total 40%) Write the mechanistic steps for the following reactions:

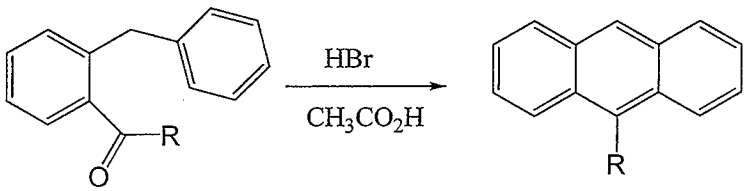
1)



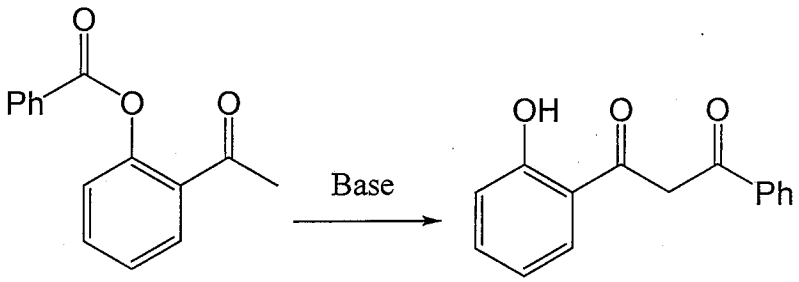
2)


OH
+ H3C—C(=O)—CH3
H3PO4
HO
CH3
C
CH3
OH

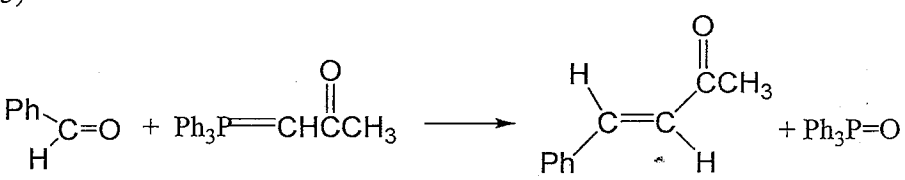
3)


R
O
HBr
CH3CO2H
R

4)


Ph
O
O
O
Base
OH
O
O
Ph

5)


Ph
C=O
H
+ Ph3P=CHCCH3
O
H
CCH3
C=C
Ph
H
+ Ph3P=O

國立中山大學101學年度碩士暨碩士專班招生考試試題

科目：工程數學【材光系碩士班乙組】

題號：4100

1. Find the solution for the following differential equation:

$$y^{iv}+4y=0,\ y(0)=\frac{1}{2},\quad y'(0)=-\frac{3}{2},\quad y''(0)=\frac{5}{2},\quad y'''(0)=-\frac{7}{2}$$ (10%)

2. Find the general solution for the following differential equation:

$$y'=\tfrac{1}{x}y^2+\tfrac{1}{x}y-\tfrac{2}{x}$$ (10%)

3. Given the 2nd-order differential equation: $y''+p(x)y'+q(x)y=r(x)$. Assume $y_1(x)$ and $y_2(x)$ are the homogeneous solutions, prove that the particular solution

$$y_p(x)=-\int\frac{y_2 r}{y_1y_2'-y_2y_1'}y_1+\int\frac{y_1 r}{y_1y_2'-y_2y_1'}y_2$$ (15%)

4. Find a general solution in terms of J_v and Y_v for $y''+k^2x^2y=0,(y=u\sqrt{x},\ \frac{1}{2}kx^2=z)$.

Indicate whether you could also use J_{-v} instead of Y_v. (10%)

5. Find solution by using Laplace transform method

$$y''+y=2t\quad y(\frac{1}{4}\pi)=\frac{1}{2}\pi, y'(\frac{1}{4}\pi)=2-\sqrt{2}$$ (15%)

6. (a) Find the Fourier coefficients and its corresponding Fourier series of the periodic function $f(x)$. The formula is $f(x)=\begin{cases}0 & \text{if } -\pi<x<0\\ x^2 & \text{if } 0\le x\le\pi\end{cases}$ and $f(x+2\pi)=f(x)$

(b) Find the value of $\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{n^2}$ (20%, each 10%)

7. Solve the following PDE:

$$\frac{\partial u}{\partial t}=c^2\frac{\partial^2 u}{\partial x^2}$$

$$u(x,0)=A_0,\quad u(0,t)=0,\ u(\infty,t)=A_0$$ (20%)

where $\left(L\left[erfc\left(\frac{a}{2\sqrt{t}}\right)\right]=\frac{e^{-a\sqrt{s}}}{s}\right)$.

國立中山大學 101 學年度碩士暨碩士專班招生考試試題

科目：光電概論【材光系碩士班丙組】

題號：4101

Electrostatic Fields

1. A cloud of charge is distributed with density $\rho = \rho_0(r/a)$, where ρ_0 is a constant, over a sphere volume of radius **a**.
   (a) Find the electric field intensity and the potential distribution in the region of $r < a$. (10%)
   (b) Determine the electric energy store in the system. (10%)

2. A cylindrical capacitor shown in Fig. 1 consists of an inner conductor of a radius **a** and an outer conductor whose inner radius is **b**. The region between the conductors is filled with a dielectric of non-uniform permittivity $\varepsilon = \varepsilon_0 b/r$. Assume the inner conductor is maintained at a potential V_0 and the outer conductor is grounded. Answer the following questions:
   (a) Determine the potential distribution between the conductors. (10%)
   (b) Find the expression for the capacitance of the cylindrical capacitor. (10%)

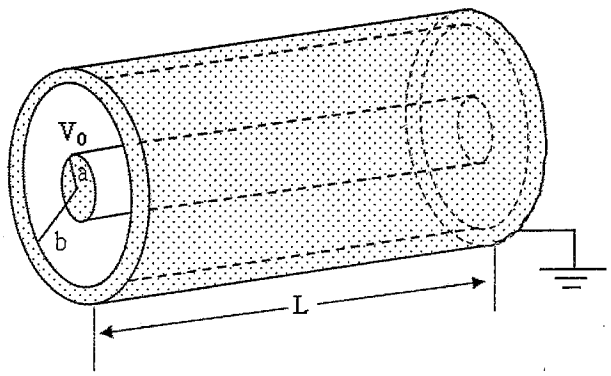


Fig. 1

3. Draw the systems of image charges that will replace the conducting boundaries that are maintained at zero potential for an infinite line charge ρ_l located midway between two large, intersecting conducting planes forming 45-degree angle. (10%)

國立中山大學 101 學年度碩士暨碩士專班招生考試試題

科目：光電概論【材光系碩士班丙組】

題號：4101

Photo detectors

4. A PN photodiode consists of a p-doped and n-doped layer. When the reverse bias current is applied, the depletion layer widens, and the potential barrier becomes even higher than in the open-circuit case. Any incident photon that has energy larger than the bandgap may give up this energy by exciting an orbit electron from the valance band into the conduction band. Thus, in a photodiode, a photon of energy hv is absorbed, creating an electron-hole pair. The electrons will flow out of the photodiode and into the external electrical circuit to produce a useful electric signal. It has been shown that the produced current i for a given light power P_{in} is given by

$$i = \eta \frac{e}{hv} P_{in},$$

where i is the electric current, η is the quantum efficiency, h is the Plank constant ($h = 6.626\times10^{-34}$ J·sec.), ν is the frequency of the light, and e denotes the elementary charge, i.e., $e = 1.6\times10^{-19}$C. The unit of i is Amp, while that of P_{in} is Watt.

Now a Silicon photodiode connected with a battery V_s and a load resistor R is designed to generate an electric current of 33.6μA, as shown in Fig. 2. The bandgap of Silicon is 1.12eV. Assume that $V_s = 3.0$ Volt, $R = 500\Omega$, and $\eta = 0.5$. Please answer the following questions:

(a) The longest wavelength of the incident photon which can be absorbed by the photodiode is identified as the cutoff wavelength. What is cutoff wavelength of the incident photon? (20%)

(b) What is the required light power P_{in} for the case of question (a)? (30%)

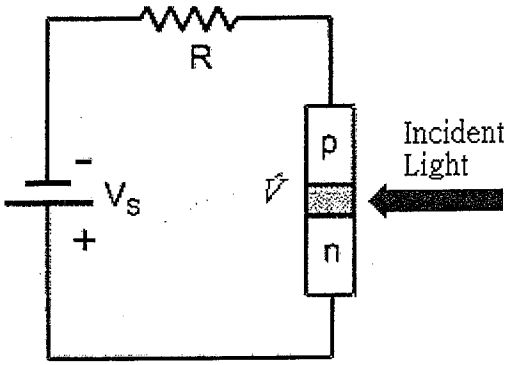


Fig. 2.

國立中山大學101學年度碩士暨碩士專班招生考試試題

科目：材料科學【材光系碩士班丙組】

題號：4103

(1) Derive Fick's second law for diffusion. For each step of your derivation, you must explain the meaning of your equation, otherwise, you will not be able to gain any score! 8 points

(2) An important property of a material is its strength. Explain what is the strength of a material? 8 points

(3) What is the importance of phase diagrams in materials science? 8 points

(4) Why the properties of a material in single crystal form are very much different from the properties of the material in polycrystal form? 8 points

(5) What are the factors that may cause the formation of grain boundary precipitation-free zone in a precipitation-hardened alloy? 8 points

(6) Give a schematic drawing that has 3m symmetry. 8 points

(7) Describe the detailed specimen preparation procedure for metallic materials to be examined under an optical microscope. 8 points

(8) In a stainless steel, partial dislocation pairs with Burgers vectors of $1/6[11\bar{2}]$ and $1/6[\bar{1}2\bar{1}]$ are found. What may be the slip lane of these partial dislocations? Under what situation, these partial dislocations can cross-slip? If these partial dislocations would be able to cross-slip, what would be the cross-slip plane? 8 points

(9) Explain the following terms:

(a) Misorientation of a grain boundary, 4 points

(b) Dielectric material, 4 points

(c) Hall effect, 4 points

(d) Piezoelectric materials 4 points

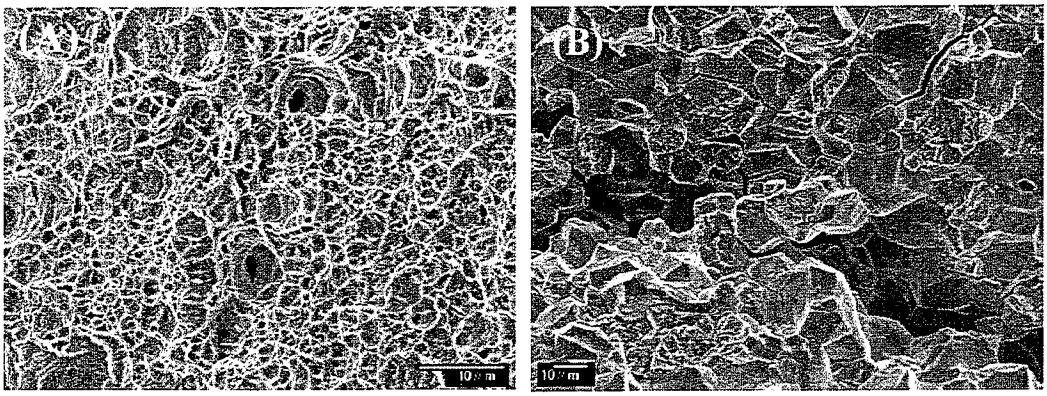
(e) Soft magnetic material. 4 points

(10) By studying the fracture surface of a material, we can obtain useful information of this material. The photos shown below are taken from two different steels. Discuss the fracture mode of these two steels. 8 points

國立中山大學101學年度碩士暨碩士專班招生考試試題

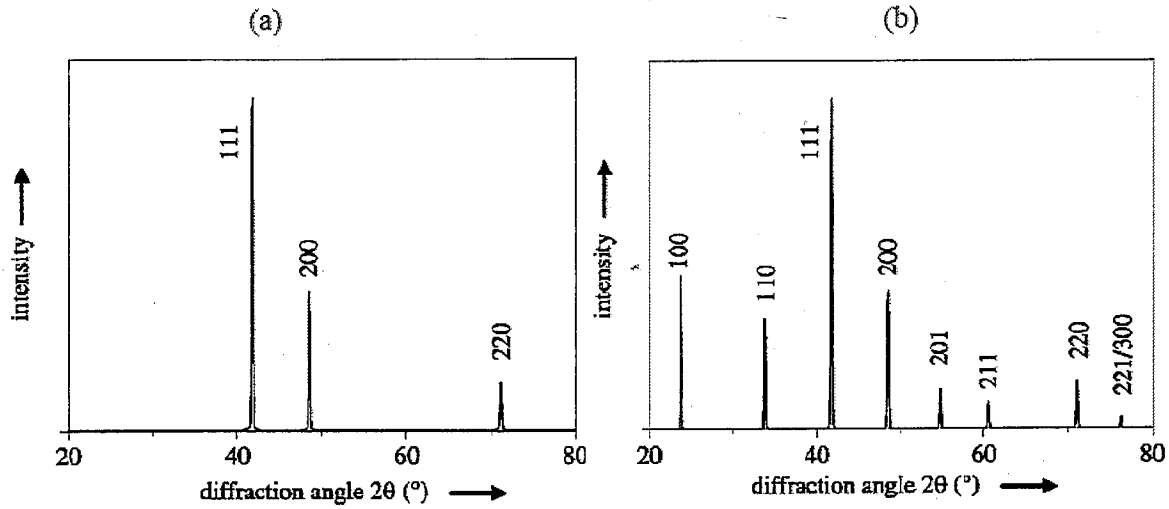
科目：材料科學【材光系碩士班丙組】

題號：4103



(11) The structure of an fcc alloy was studied by X-ray diffractometer. After two different heat treatment conditions, two different diffraction patterns were obtained, as shown below. Discuss the effect of heat treatment on the structure of this alloy.

8 points



國立中山大學 101 學年度碩士暨碩士專班招生考試試題

科目：物理化學【材光系碩士班甲組】

1. Show that, if S is regarded as a function of T and V, then
$$\Delta S = nC_v \ln(\frac{T_2}{T_1}) + nR\ln(\frac{V_2}{V_1})$$ (10%)

2. Derive the Maxwell relation below $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$ (10%)

3. The osmotic pressure of solution of poly(vinyl chloride), PVC, in cyclohexane at 298 K are given below. The pressure are expressed in terms of the highest of solution (mass density = 0.98 g/cm^3) in balance with the osmotic pressure. Determine the molar mass of polymer by following data

c(gL^{-1})	1.0	2.0
h/cm	0.28	0.71

(10%)

4. (a) Explain the term "surface tension" and give its definition
(b) In a capillary tube of radius r, you have a liquid density d, and surface tension σ. The rise of liquid level is h. Please derive the following equation $h = \frac{2\sigma}{dgr}$ (10%, each 5%)

5. Suppose that in an industrial batch process a material A produces the desire material B (the rate constant is k_a) which goes on to decay a worthless product C (the rate constant is k_b), each step of reaction being first order.
(a) Derive the expression for the variations of [A], [B], and [C] with time. (10%)
(b) At what time does the concentration of B reach a maximum? (5%)

6. Show that the Dieterici equation $P = \frac{RT}{V_m - b}\exp(-\frac{a}{RTV_m})$ is mathematically similar to van der Waals equation at high temperature or low density (i.e. when $\frac{a}{RTV_m} << 1$) (15%)

7. Helium is compressed isothermally and reversibly at 100 °C from a pressure of 2 to 10 bar. Calculate (a) heat, q, (b) work, w, (c) △G, (d) △H, and (e) △S per mole, assuming Helium is an ideal gas. (15%, each 3%)

8. When 1 mole of water supercooled to -10 °C freezes isothermally, what are the entropy change of the system and surroundings? Give the molar enthalpy of the melting of ice at 0 °C is 6025 J/mol, the molar heat capacities of ice and water are 37.3 and 75.3 J/mol.K, respectively. (15%)

國立中山大學101學年度碩士暨碩士專班招生考試試題

科目：熱力學【材光系碩士班乙】

題號：4015

請於答案卷上依序作答，並清楚標明題號

1. A pressure cooker cooks a lot faster than an ordinary pan by maintaining a higher pressure and temperature inside. The lid of a pressure cooker is well sealed, and steam can escape only through an opening in the middle of the lid. A separate metal piece, the petcock, sits on top of this opening and prevents steam from escaping until the pressure force overcomes the weight of the petcock. The periodic escape of the steam in this manner prevents any potentially dangerous pressure buildup and keeps the pressure inside at a constant value. Determine the mass of the petcock of a pressure cooker whose operation pressure is 100 kPa gage and has an opening cross-sectional area of 4 mm^2. Assume an atmospheric pressure of 101 kPa. (15%)
2. The densities of solid and liquid bismuth are 9.673 and 10.0 g/ cm^3 respectively at the normal melting point 270 °C . The heat of fusion of bismuth is 11.02 kJ/mol. Calculate the change in melting point of bismuth under a pressure of 100 atm. Atomic weight of bismuth is 209 [hint: 1 joule = 9.87 cm^3 . atm] (20%)
3. The Fe and O phase diagram has three stoichiometric compounds, FeO, Fe_3O_4 and Fe_2O_3. There is a composition X as 24 wt% O, 76 wt% Fe in the system Fe-O. This composition X can equivalently be calculated as being in the following two systems. (a) the system Fe-Fe_3O_4,(10%) and (b) the system FeO – Fe_3O_4. (10%) [Fe atomic weight: 56, O_2 atomic weight: 32]
4. The initial state of one mole of a monatomic ideal gas is P=10 atm and T=300 K. calculate the change in entropy of the gas for (a) an isothermal decrease in the pressure to 5 atm; (6%)(b) a reversible adiabatic expansion to a pressure of 5 atm;(6%) (c) a constant-volume decrease in the pressure to 5 atm. (8%)
5. The molar excess Gibbs free energy of formation of a binary A-B solution is given as $G^{xs} = (a + bX_B)X_AX_B$; the constants a and b are simply parameters the value of which can be adjusted in an attempt to fit the equation to experimentally measured data. Derive expressions for the partial molar excess Gibbs free energies of the components A and B. (25%)