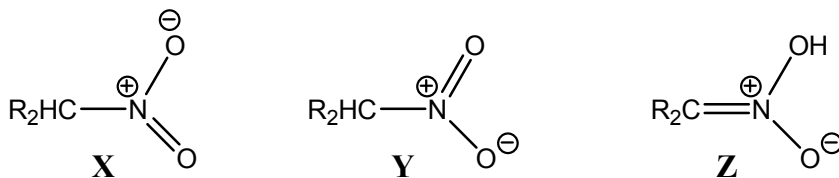


## IIT-JAM Chemistry Paper-2008

## Instruction:

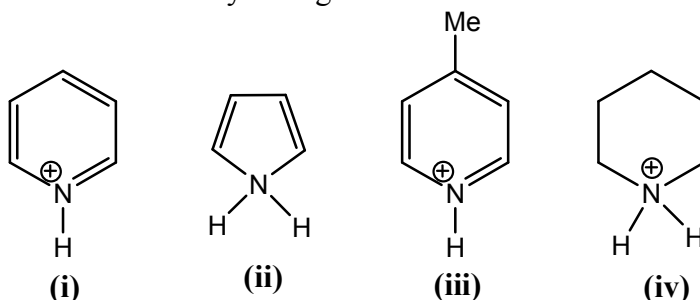
Q.1-30 (Objective questions) carry *three* marks each and Q.31-44 (Subjective questions) carry *fifteen* marks each.

1. The correct statement describing the relationship between



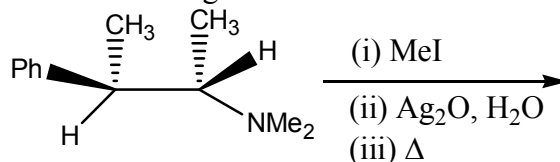
is:

- (a) X and Y are resonance structures and Z is a tautomer  
 (b) X and Y are tautomers and Z is a resonance structure.  
 (c) X, Y and Z are all resonance structures.  
 (d) X, Y and Z are all tautomers.
2. Among the following, the correct statement concerning the optical activity is:  
 (a) A molecule containing two or more chiral centres is always optically active.  
 (b) A molecule containing just one chiral centre is always optically active  
 (c) A molecule possessing alternating axis of symmetry is optically active.  
 (d) An optically active molecule should have at least one chiral centre.
3. The correct order of acidity among.



is:

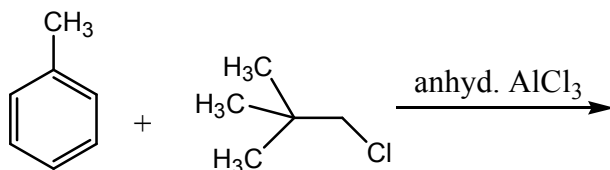
- (a) (i) < (ii) < (iii) < (iv)                      (b) (iv) < (i) < (iii) < (ii)  
 (c) (ii) < (i) < (iii) < (iv)                      (d) (ii) < (iv) < (i) < (iii)
4. The major product obtained in the following reaction.



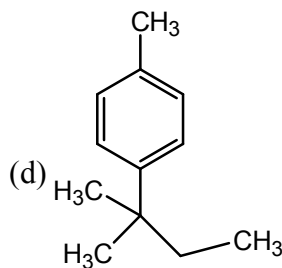
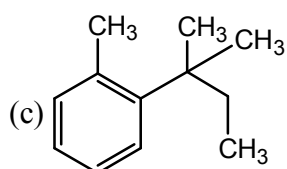
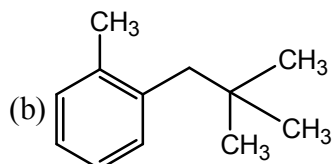
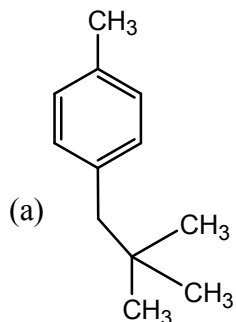
is:

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

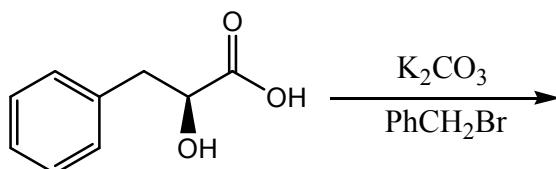
5. The major product of the following reaction



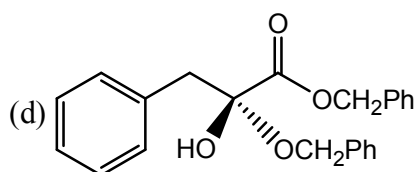
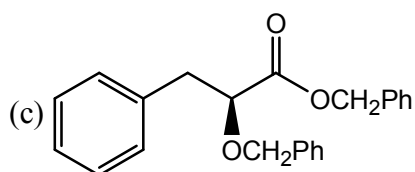
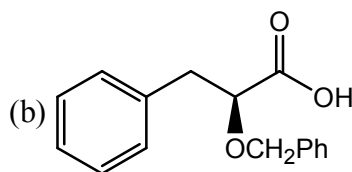
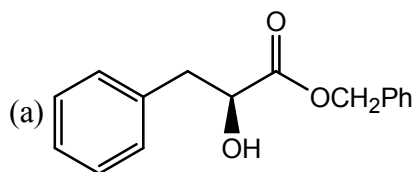
is:



6. The major product obtained in the following reaction



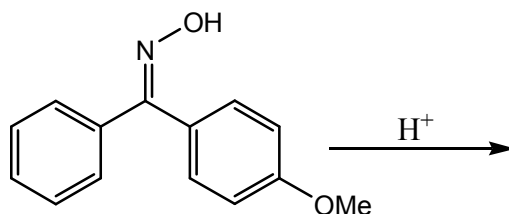
is:



7. R-(−)-2-Bromooctane on treatment with aqueous KOH mainly gives 2-octanol that is:

- (a) Optically active with 'R' configuration      (b) Optically active with 'S' configuration  
 (c) A racemic mixture      (d) A meso compound

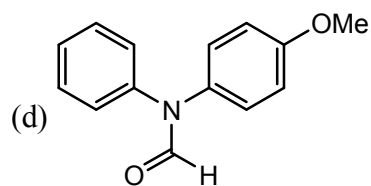
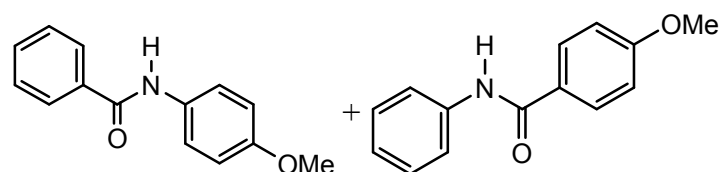
8. The major product obtained in the following reaction



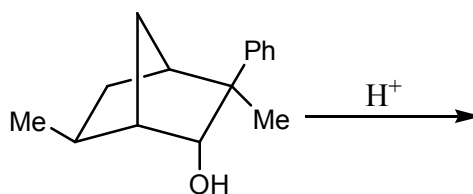
is:



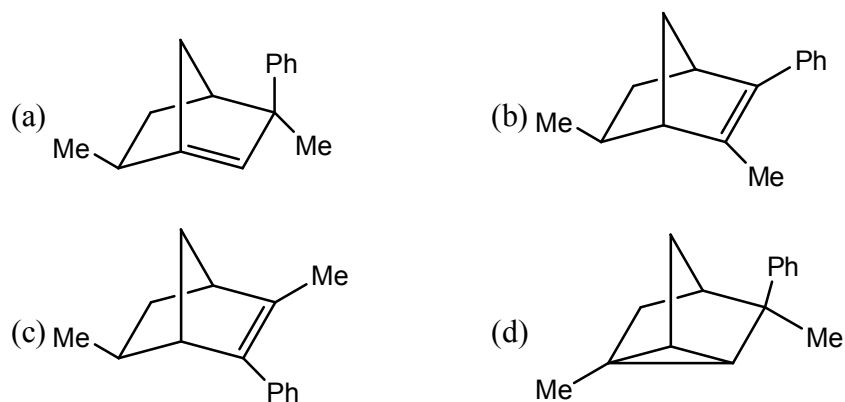
(c) An equimolar mixture of



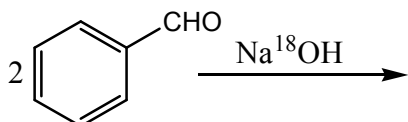
9. The major product obtained in the following reaction



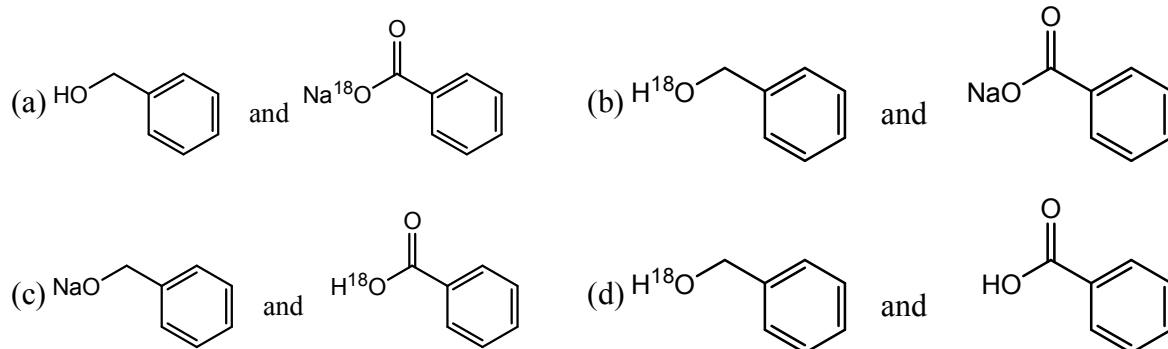
is:



10. The products of the following reaction



are



11. When one mole of ice is converted to water at 0°C and 1 atm, the work done (1 atm) is:

- (a)  $1.1 \times 10^{-4}$  (b)  $2.0 \times 10^{-3}$  (c)  $2.0 \times 10^{-4}$  (d)  $1.1 \times 10^{-5}$ .

12. When 100 g of water is reversibly heated from 50°C to 75°C at 1 atm, the change in entropy ( $\text{JK}^{-1}$ ) of the universe is:

- (a) -0.31 (b) 0.31 (c) 0 (d) 3.1

13. For a zero order reaction, units of the rate constant is expressed as

- (a)  $M^1 s^{-1}$  (b)  $M^0 s^{-1}$  (c)  $M^{-1} s^{-1}$  (d)  $M^0 s^0$

14.  $1 \times 10^{-6}$  moles of the enzyme carbonic anhydrase dehydrates  $\text{H}_2\text{CO}_3$  to produce 0.6 mol of  $\text{CO}_2$  per second. The turnover number of the enzyme is:

- (a)  $N_A \times 6 \times 10^{-5}$  (b)  $(1/6) \times 10^{-5}$  (c)  $(6 \times 10^5) / N_A$  (d)  $6 \times 10^5$

15. Given that the most probable speed of oxygen gas is  $1000 \text{ ms}^{-1}$ , the mean/average speed ( $\text{ms}^{-1}$ ) under the same conditions is:

- (a) 1224 (b) 1128 (c) 886 (d) 816

16. If the electron were spin  $3/2$  particles, instead of spin  $1/2$ , then the number of electrons that can be accommodated in a level are

- (a) 2 (b) 3 (c) 4 (d) 5

17. For a particle in a cubic box, the total number of quantum numbers needed to specify its state are

- (a) 1 (b) 3 (c) 4 (d) 9

18. The maximum number of phases that can co-exist in equilibrium for a one component system is:

- (a) 1 (b) 2 (c) 3 (d) 4

19. With increasing pressure, the temperature range over which the liquid state is stable.

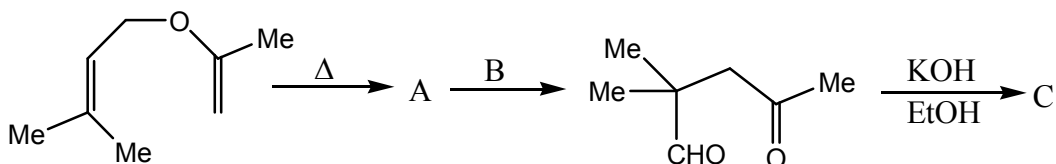
- (a) Decreases (b) Increases  
(c) Remains constant (d) Decreases till the critical pressure and then increases.

20. The conductance at infinite dilution follows the order

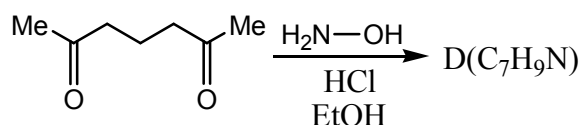
- (a)  $\text{Li}^+ > \text{Na}^+ > \text{K}^+$  (b)  $\text{Na}^+ > \text{Li}^+ > \text{K}^+$  (c)  $\text{K}^+ > \text{Li}^+ > \text{Na}^+$  (d)  $\text{K}^+ > \text{Na}^+ > \text{Li}^+$

21. The V-shape of  $\text{SO}_2$  is due to the presence of  
 (a) Two  $\sigma$  – and one  $\pi$  – bonds.  
 (b) Two  $\sigma$  – and two  $\pi$  – bonds.  
 (c) Two  $\sigma$  – bonds and one lone pair of electrons  
 (d) Two  $\sigma$  – and two  $\pi$  – bonds, and one lone pair of electrons.
22. The correct order of the mean bond energies in the binary hydrides is:  
 (a)  $\text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O} > \text{HF}$  (b)  $\text{NH}_3 > \text{CH}_4 > \text{H}_2\text{O} > \text{HF}$   
 (c)  $\text{HF} > \text{H}_2\text{O} > \text{CH}_4 > \text{NH}_3$  (d)  $\text{HF} > \text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4$
23. In CsCl structure, the number of  $\text{Cs}^+$  ions that occupy second nearest neighbour locations of a  $\text{Cs}^+$  ion is:  
 (a) 6 (b) 8 (c) 10 (d) 12
24. In the process  

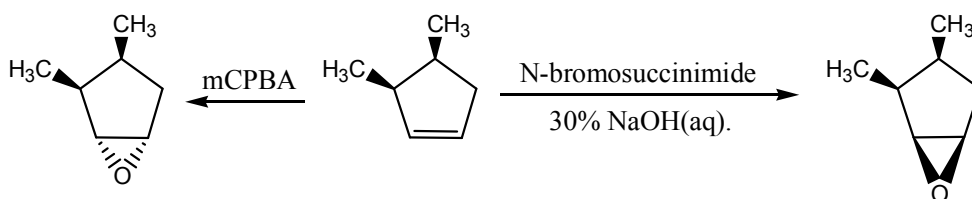
$${}_{92}^{234}\text{U} \longrightarrow {}_{90}^{230}\text{Th} + \text{X}$$
  
 X is:  
 (a)  $\alpha$  particle (b)  $\beta$  – particle (c)  $\beta^+$  – emission (d)  $\gamma$  – emission
25. For tetrahedral complexes, which always exhibit high spin states, the maximum CFSE (crystal field stabilization energy) is:  
 (a) -8 Dq (b) -12 Dq (c) -16 Dq (d) -20 Dq
26. The most abundant element in earth's crust is:  
 (a) Aluminium (b) Iron (c) Silicon (d) Oxygen
27. Metal-carbon multiple bonds in metal carbonyl are preferably identified from the stretching frequency of  
 (a) Carbon-oxygen bond (b) Metal-carbon bond  
 (c) Metal-oxygen bond (d) Carbon-carbon bond
28. In general, magnetic moment of paramagnetic complexes varies with temperature as  
 (a)  $T^2$  (b)  $T$  (c)  $T^2$  (d)  $T^{-1}$ .
29. The compound having an S-S single bond is:  
 (a)  $\text{H}_2\text{S}_2\text{O}_3$  (b)  $\text{H}_2\text{S}_2\text{O}_4$  (c)  $\text{H}_2\text{S}_2\text{O}_7$  (d)  $\text{H}_2\text{S}_2\text{O}_8$
30. In a reaction,  $\text{Na}_2\text{S}_2\text{O}_3$  is converted to  $\text{Na}_2\text{S}_4\text{O}_6$ . The equivalent weight of  $\text{Na}_2\text{S}_2\text{O}_3$  for this reaction is (mol. wt. of  $\text{Na}_2\text{S}_2\text{O}_3 = M$ )  
 (a) M (b) M/4 (c) M/2 (d) M/3
31. (a) Identify A, B and C in the following reaction sequence.



- (b) Identify D in the following reaction and suggest a suitable mechanism for its formation.

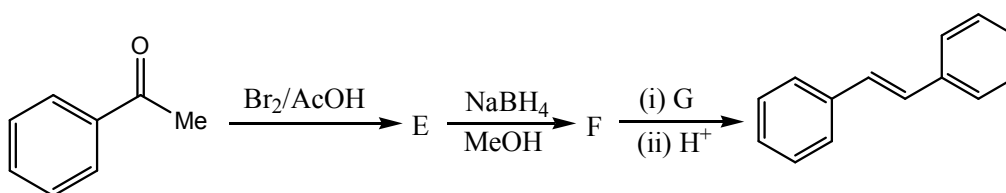


32. (a) Explain with the help of mechanisms, the observed stereoselectivity in the following epoxide formation reactions.



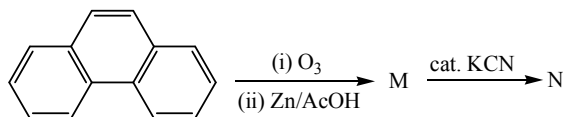
(b) Explain on the basis of conformational analysis why (1R, 2S)-1, 2-dimethyl-cyclohexane is optically inactive at room temperature.

33. (a) Identify E, F and G in the following synthetic transformation:

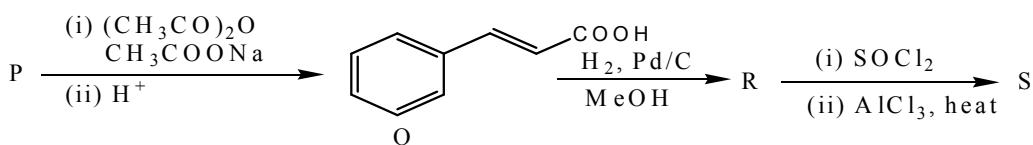


(b) An optically active compound H ( $C_5H_6O$ ) on treatment with  $H_2$  in the presence of Lindlar's catalyst gave a compound I ( $C_5H_8O$ ). Upon hydrogenation with  $H_2$  and Pd/C, compound H gave J ( $C_5H_{12}O$ ). Both I and J were found to be optically inactive. Identify H, I and J.

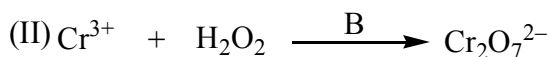
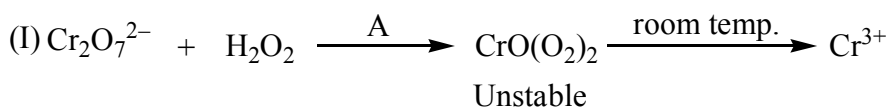
34. (a) A disaccharide K gives a silver mirror with Tollen's reagent. Treatment of K with MeOH/HCl gives a monometry derivative L, which does not react with Tollen's reagent. Methylation of K with  $Me_2SO_4$  and NaOH affords an octamethyl derivative of K, which upon acidic hydrolysis gives a 1:1 mixture of 2, 3, 4, 6-tetra-O-methyl-D-glucose and 2, 3, 4-tri-O-methyl-D-glucose. Disaccharide K is also hydrolysed by the enzyme maltase. Identify K and L with proper stereochemistry.  
 (b) Identify M and N in the following reaction sequence.



35. In the following reaction sequence, identify P, R and S. Suggest suitable mechanism for the conversion of  $P \rightarrow Q$  and  $R \rightarrow S$ .



36. (a) Consider the reactions.



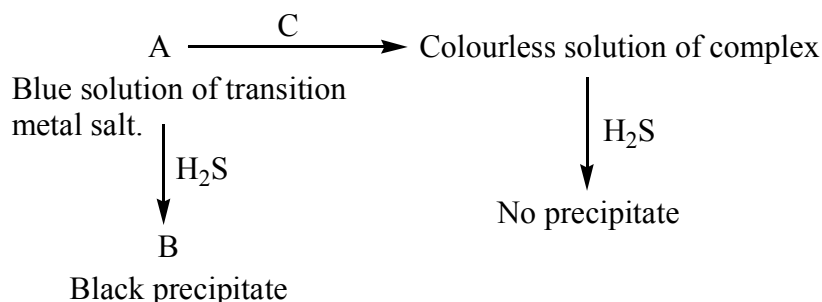
(i) Identify A and B.

(ii) What is the role of  $H_2O_2$  in (I) and how does A favour the formation of  $Cr^{3+}$ ?

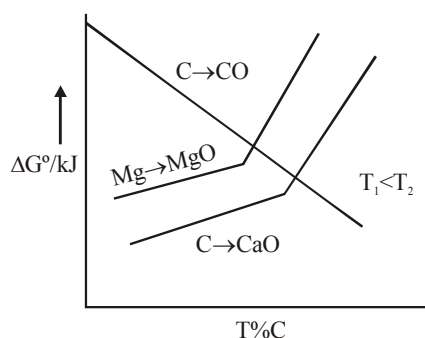
(iii) What is the role of  $H_2O_2$  in (II) and how does B favour the formation  $CrO_4^{2-}$ ?

(b) With the help of equations, illustrate the role of a cis-1, 2-diol in the titration of boric acid with sodium hydroxide.

37. (a) Draw the structure of anionic Ca(II)-EDTA chelate. How many rings are formed in the chelate and specify the number of atoms in each ring?  
 (b) Based on VSEPR theory draw the most stable structure of  $\text{ClF}_3$  and  $\text{XeF}_4$ .
38. (a) Identify A, B and C in the following reaction scheme



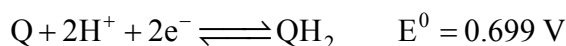
- (b) From the Ellingham diagram given below, identify the metal oxide that can be reduced at a lower temperature by carbon. Justify.



39. (a) For the complexes  $[\text{FeF}_6]^{3-}$  and  $[\text{Fe}(\text{CN})_6]^{3-}$ .  
 (i) Show the hybridization using VB (valence bond) theory  
 (ii) Calculate the CFSE (crystal field stabilization energy)
- (b) Identify the dark blue complex formed when  $[\text{Fe}(\text{CN})_6]^{3-}$  is treated with  $\text{FeSO}_4$  and account for the origin of its colour.
40. (a) Consider the equilibrium,  $\text{A}(\text{g}) \rightleftharpoons \text{B}(\text{g}) + \text{C}(\text{g})$

At a constant pressure of 1 atm, A dissociates to the extent of 50% at 500 K. Calculate  $\Delta G^0$  ( $\text{kJ mol}^{-1}$ ) for the reaction.

- (b) Consider the following redox system.

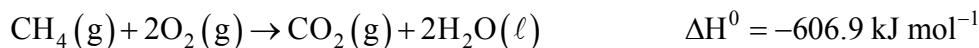


Calculate the pH of the solution at 298 K, if the redox potential of the system is 0.817 V.

41. (a) A stream of oxygen molecules at 500 K exits from a pin-hole in an oven and strikes a slit that selects the molecules travelling in a specific direction. Given that the pressure outside the oven  $2.5 \times 10^{-7}$  atm, estimate the maximum distance at which the slit must be placed from the pin-hole, in order to produce a collimated beam of oxygen. (Radius of  $\text{O}_2 = 1.8 \times 10^{-10}$  m)
- (b) Liquid water is to be circulated to transfer heat from a source to a sink at 1 atm. Considering this arrangement as a Carnot engine, calculate the maximum theoretical efficiency that can be expected from the system.

42. (a) Using Heisenberg's uncertainty principle, derive an expression for the approximate ground state energy of a particular of mass  $m$  in a one dimensional box of length  $L$ .  
 (b) The rate of a chemical reaction doubles when the temperature is changed from 300 K to 310 K. Calculate the activation energy ( $\text{kJ mol}^{-1}$ ) for the reaction.

43. (a) Consider the reaction.



Assuming ideal behaviour, calculate  $\Delta U^\circ$  when 1 mol of  $\text{CH}_4$  is completely oxidized at STP.

- (b) A photochemical reaction was carried out using monochromatic radiatin (490 nm) of intensity 100 W. When the sample was irradiated for 30 min, 0.3 mol of the reactant was decomposed. Estimate the quantum efficiency assuming 50% absorption.
44. (a) Given that

$$C_p - C_v = \frac{\alpha^2 TV}{\kappa_T} \quad \text{where } \alpha = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_p \quad \text{and } \kappa_T = -\frac{1}{V} \left( \frac{\partial V}{\partial P} \right)_T$$

for a pure substance, show that  $C_p - C_v = R$  for 1 mol of an ideal gas.

- (b) Find the eigenvalues of the following  $3 \times 3$  marix given that 2 is one of the eigenvalues. Compute the determinant of matrix **using the eigenvalues**.

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -2 \\ 1 & -1 & 1 \end{pmatrix}$$