國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

科目：物理化學

1. The molar entropy of argon (Ar) at 298 K is $154.8\ \mathrm{J\ mol^{-1}\ K^{-1}}$. Calculate the molar entropy of a constant-volume sample of argon at 350 K. The heat capacity at constant pressure of argon is $20.8\ \mathrm{J\ mol^{-1}\ K^{-1}}$. (12%)

2. In the gas-phase reaction $2\mathrm{A} + \mathrm{B} \rightleftharpoons 3\mathrm{C} + 2\mathrm{D}$, it was found that, when 2.0 mol A, 4.0 mol B and 2.0 mol C were mixed and allowed to come to equilibrium at 298 K, the resulting mixture contained 1.2 mol D at a total pressure of 2.0 bar. Calculate (a) the mole fractions of each species at equilibrium, (b) the equilibrium constant ($K$) and (c) the standard Gibbs energy of reaction ($\Delta_r G^{\ominus}$). (18%)

3. The rate constant for the first-order decomposition of a compound A in the reaction $4\mathrm{A(g)} \longrightarrow \mathrm{B(g)}$ is $k_r = 12.48 \times 10^{-6}\ \mathrm{s^{-1}}$ at 325 K. The initial pressure of A is 40 kPa. (a) What is the half-life of A? (b) What is the time constant of A? (c) What will be the pressure of A and B after 2 hours of reaction? (20%)

4. In the cell $\mathrm{Ag|AgCl}(s)\mathrm{|AgCl}(aq)\mathrm{|Ag}$ the two reduction half-reactions and their standard potentials at 298 K are:

$$\mathrm{AgCl}(s) + e^- \rightarrow \mathrm{Ag}(s) + \mathrm{Cl}^-(aq) \qquad +0.22\ \mathrm{V}$$

$$\mathrm{Ag}^+(aq) + e^- \rightarrow \mathrm{Ag}(s) \qquad +0.80\ \mathrm{V}$$

Please calculate (a) the cell potential and (b) the solubility product of AgCl and (c) its solubility. (18%)

5. A sample consisting of 2.00 mole of diatomic perfect gas molecules at 25 °C is compressed reversibly and adiabatically until its temperature reaches 125 °C. Given that $C_{V,m} = 27.5\ \text{J mol}^{-1}\ \text{K}^{-1}$, calculate $q$, $w$, $\Delta U$, $\Delta H$ and $\Delta S$. (20%)

6. At 300K the partial vapor pressure of HA in liquid $GeCl_4$ are shown in the following Table.

| $x_{HA}$ | 0.012 | 0.015 | 0.021 |
|---|---|---|---|
| $p_B$/kPa | 76.8 | 96.1 | 134.3 |

(a) Calculate Henry's law constant at 300 K.

(b) Predict the particle vapor pressure of this acid, HA, above its solution in liquid $GeCl_4$ of molality $0.08\ \text{mol kg}^{-1}$. (Molar mass of $GeCl_4$ is $214.39\ \text{g mol}^{-1}$). (12%)

國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

科目：單元操作與輸送現象

1. A wall is composed of three kinds of bricks (shown as following). The indoor air is at the temperature of 80°F with heat transfer coefficient of 2.0 Btu/hr-ft$^2$-°F. The outdoor air is at the temperature of 105°F with heat transfer coefficient of 6.0 Btu/hr-ft$^2$-°F. The thickness (in) and thermal conductivity (k, Btu/hr-ft-°F) of the bricks are given in the figure. (20%)
   (a) Please calculate the heat transfer rate per unit area (Btu/hr-ft$^2$) through the wall.
   (b) Please determine the temperature at the indoor surface of the wall.

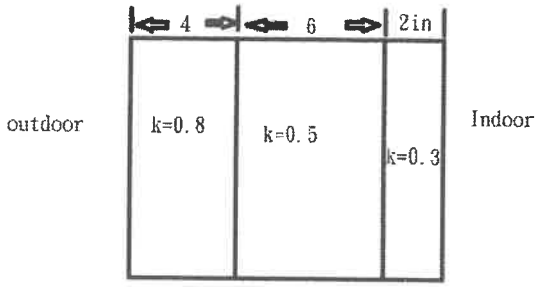


**Figure 1.**

2. A cylindrical tube is composed of two materials (shown as following). A fluid at the temperature of $T_i$ flows through the inner tube with heat transfer coefficient of $h_i$. On the other hand, another fluid at the temperature of $T_o$ flows over the outer tube with heat transfer coefficient of $h_o$. The heat transfer is assumed in the radial direction. Please derive the overall heat transfer coefficient. (20%)

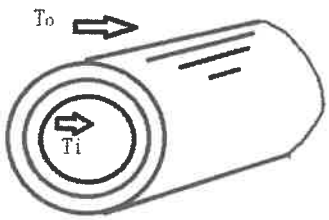


**Figure 2.**

3. Answer the followings in the fractioning process. (16%)
   (a) The physical meaning of operation line and equilibrium line in the McCabe-Thiele method for distillation.
   (b) If the overall efficiency is 75% and the numbers of ideal plates are 16, what is the number of real plates in the fractioning tower?
   (c) What are the situations when the $q$ values are 0 and 1?
   (d) What is the situation when the minimum reflux ratio occurs?

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系所：化材系

科目：單元操作與輸送現象

4. According to the film theory (referring to Figure 3), prove that the Sherwood number $Sh = \frac{k_c \delta}{D_{AB}} = 1$ where $k_c$ is the mass transfer coefficient, $\delta$ is the film thickness, and $D_{AB}$ is the diffusivity of gas A in liquid B. (20%)

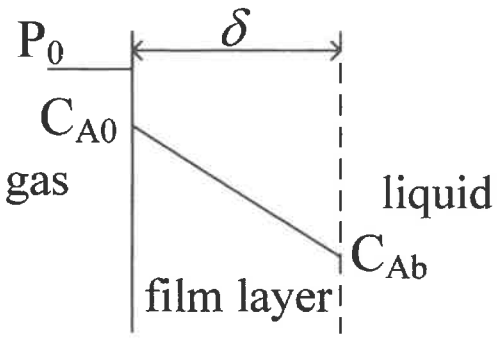



**Figure 3.**

5. Consider a pressure-driven fully-developed laminar flow of an incompressible Newtonian fluid of density $\rho$ and viscosity $\mu$ in a horizontal tube of diameter $D$ and length $L$, referring to Figure 4. (24%)

   (a) Derive the average fluid velocity, $\langle v_z \rangle$, in terms of a function of pressure drop $\Delta p$ across the tube **by using the shell momentum balance method.**

   (b) Prove that the Fanning friction factor $f_F = \frac{16}{\mathrm{Re}}$, where $\mathrm{Re} = \frac{\rho \langle v_z \rangle D}{\mu}$.

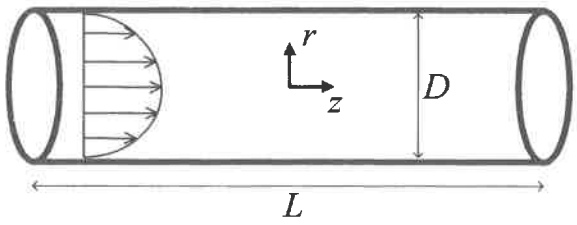



**Figure 4.**

國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

科目：化工動力學

1) (10%) Please briefly describe the characteristics, usage, advantages, and disadvantages of Continuously Stirred Tank Reactor (CSTR).

2) (10%) Please explain why third order reaction will be affected more by pressure drop than second order reaction.

3) (20%) The dimerization, $2A_{(g)} \rightarrow A_{2(g,l)}$, is carried out isothermally and without pressure drop in a PFR at 298 K and 3.5 atm. As the concentration of $A_2$ increases down the reactor and $A_2$ begins to condense. The vapor pressure of $A_2$ at 298 K is 0.5 atm. If an equal molar mixture of A and inert, I, is fed to the reactor, at what conversion of A will $A_2$ begin to condense? (**Hint**: condensation is happened at saturation vapor pressure)

4) (20%) The irreversible elementary reaction $A_{(g)} \rightarrow B_{(g)}$ is conducted in a *tubular reactor system* consisting of 40 parallel 10 m long tubes with a 5 cm inside diameter. Compound A has a molecular weight of 100 with idea gas behavior. The feeding rate is 314 kg per hour of pure A and the operating pressure of 8.2 atm. It is known that the reaction rate constant for this first-order reaction is 3 $hr^{-1}$ at 300 K and 9 $hr^{-1}$ at 400 K. What conversion can be achieved if operating temperature set at 500K?

5) (20%)The gas-phase decomposition of compound A, $A \rightarrow B+2C$, was carried out isothermally in the lab, in which the total pressure was recorded with time. The data shown in table 1 apply to this reaction and only pure A was present initially in the reactor. Please determine this reaction order by the differential method and the integral method, respectively.

Table 1.

| Time (min) | Total Pressure (mmHg) |
|---|---|
| 0 | 8 |
| 2.5 | 11 |
| 5 | 13 |
| 10 | 16 |
| 15 | 18 |
| 20 | 20 |

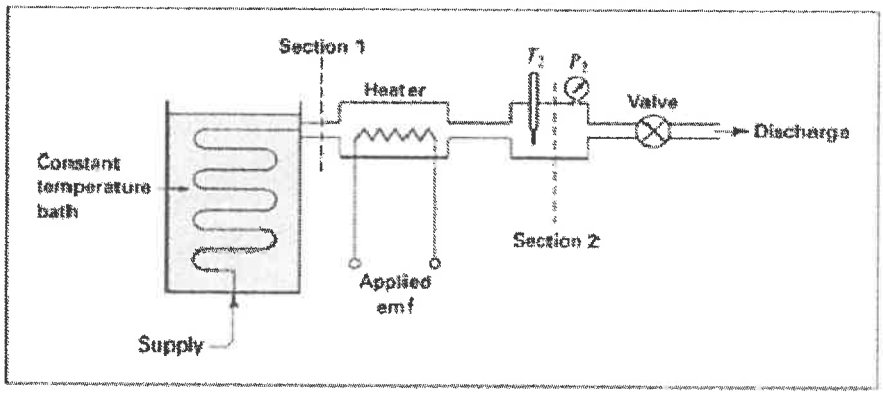
6) (20%) As an isomerization of n-pentene to i-pentene over alumina. Please show (1) adsorption, (2) surface reaction, and (3) desorption reaction mechanisms and rate expressions. If the surfactant reaction is a rate-limiting step, please derive the rate law.

國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

科目：化工熱力學

1. [12%] A simple flow calorimeter is illustrated schematically in the figure below.




1-1 What is the function for the flow calorimeter? [4%]該裝置的功能(目的)為量測流體何種熱力學性質？

1-2 Write the energy balance equation for the process, assuming that both kinetic- and potential energy are negligible and there is no shaft work. [4%]請寫出適合該裝置之能量平衡公式，假設動能、位能變化可忽略及無軸工

1-3 If the test fluid is water, flow rate = 4.15 g $s^{-1}$, $T_1$ = 0 ℃, $T_2$ = 300 ℃, $P_2$ = 3 bar, rate of heat addition from resistance heater = 12,740 W. The water is completely vaporized in the process. Calculate the enthalpy of steam at 300 ℃，3 bar based on H = 0 for $H_2O(l)$ at 0 ℃. [4%]

2. 【16%】Air flows at a steady rate through a horizontal pipe to a partly closed valve. The pipe leaving the valve is enough larger than the entrance pipe that the kinetic-energy change of the air as it flows through the valve is negligible. The valve and connecting pipes are well insulated. The conditions of the air upstream from the valve are 20℃(293.15 K) and 6 bar, and the downstream pressure is 3 bar. If air is regarded as an ideal gas, and the system is insulated, making Q negligible. The potential –energy and kinetic-energy changes are negligible.

2-1 What is ΔH value for this process? [4%]

2-2 What is the temperature of the air some distance downstream from the valve? [4%]

2-3 What is such a process called in chemical industrial application? [化工應用上，該程序的名稱為何?] [4%]

2-4 What will be the temperature change for a real gas to under a reduction of pressure in such a process?實際氣體經過此程序的減壓其溫度變化趨勢為何？[4%]

3. (12%)The residual properties can be expressed in terms of compressibility factor, z(剩餘性質可以用壓縮因子來表示) and *PVT*. For example,

3-1 $V^R \equiv V - V^{ig} = ?$[4%]

3-2 What is the relationship between fugacity coefficients $\phi_i$ (逸壓係數) and residual Gibbs free energy($\frac{G^R}{RT}$) ? [4%]

3-3 What is the value of fugacity coefficient of an ideal gas? [4%]

4. [10%] Suppose an insulated container, partitioned into two equal volumes, contains Avogadro's number $N_0$ of ideal-gas molecules in one section and on molecules in the other. When the partition is withdrawn, the molecules quickly distribute themselves uniformly throughout the total volume. The process is an adiabatic expression that accomplishes no work.假設一絕熱容器以一隔板隔開兩等份體積，其中一半體積內含有亞佛加厥數 $N_0$ 的理想氣體分子，當隔板移開，分子很快均勻分布在全部體積，該程序為絕熱且無做功。

國立雲林科技大學 107 學年度 系所：化材系
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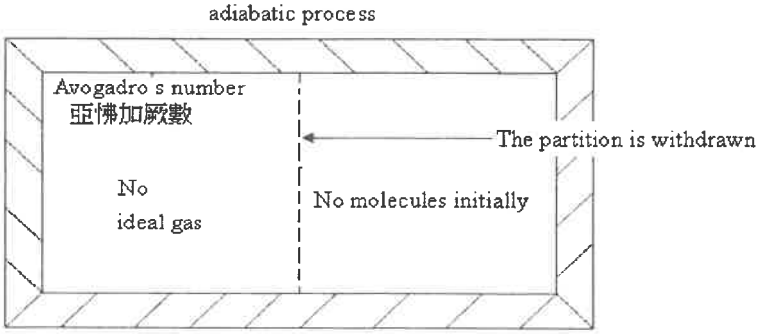



4-1 What is the ΔT for this process? [3%]

4-2 What is the ΔU for this process? [3%]

4-3 What is the ΔS for this process? [4%]

5. 針對一理想氣體，又 $(\partial U/\partial T)_P = C_v$，試導證 $C_{P,m} - C_{v,m} = R$ ，其中U為內能，T為溫度，P為壓力，$C_v$為定容熱容量，$C_{P,m}$為莫耳定壓熱容量，$C_{v,m}$為莫耳定容熱容量，R為氣體常數。（15 %）

6. 1 莫耳（mole）水置於一開口燒杯中於 298 K 完全蒸發成為水蒸氣(假設理想氣體)，試計算水蒸氣對 大氣(假設恆壓)所作可逆功(work)。($R = 8.314\ J\ K^{-1}\ mol^{-1}$)（10 %）

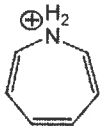
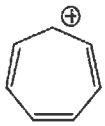
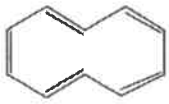
7. 1 莫耳（mole）理想氣體經定壓可逆程序，由 298 K 升溫到 573 K，又知其定壓熱容量 $C_p(J\ K^{-1}) = 20.17 + 0.0366T(K)$，試計算此程序的熱(heat)、功(work)、內能(internal energy)變化(△U)與焓(enthalpy)變化(△H)。($R = 8.314\ J\ K^{-1}\ mol^{-1}$)（25 %）

國立雲林科技大學 107 學年度 碩士班招生考試試題

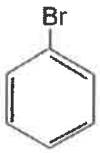
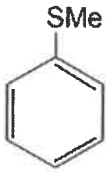
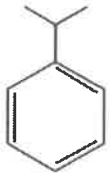
系所：化材系

科目：有機化學

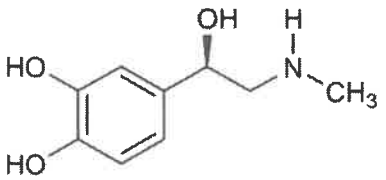
1. (a) Which of the following compounds is likely to adopt a planar conformation? (3%)

(1)  ; (2)  ; (3)  ; (4) 

(b) Which of the following would be most reactive with $Br_2$ in the presence of $FeBr_3$? (3%)

(1)  ; (2)  ; (3)  ; (4) 

(c) Epinephrine is a hormone and neurotransmitter produced by the adrenal medulla and has the following structure. Choose the statement that correctly identifies some of the functional groups present in epinephrine.



epinephrine

(1) alcohol, ester, aromatic; (2) amine, alcohol, amide; (3) amide, aromatic, alkane; (4) amine, alcohol, aromatic; (5) alkane, ether, aromatic. (3%)

(d) Which of the following would be the most likely to undergo a nucleophilic aromatic substitution with hydroxide ion in normal conditions? (1) Chlorobenzene; (2) benzoic acid; (3) benzene; (4) p-chlorotoluene; (5) 2,4,6-trinitro-1-chlorobenzene. (3%)

(e) Which of the following would be *incorrect* about rings?

(1) The chair conformation of cyclohexane has no angle or torsional strain; (2) planar cyclobutane is its most stable conformation; (3) cyclopropane has the greatest angle strain; (4) planar cyclopentane would have small angle strain but severe torsional strain; (5) the chair conformation has less torsional strain and fewer nonbonded interactions than the twist boat conformation. (3%)

國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

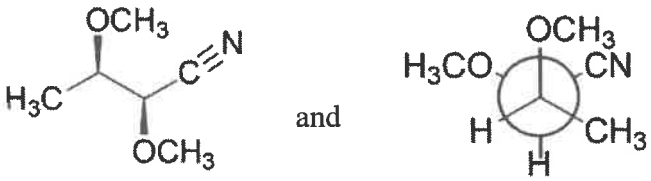
科目：有機化學

2. Label each pair as enantiomers, diastereomers, or same molecule. (15%)

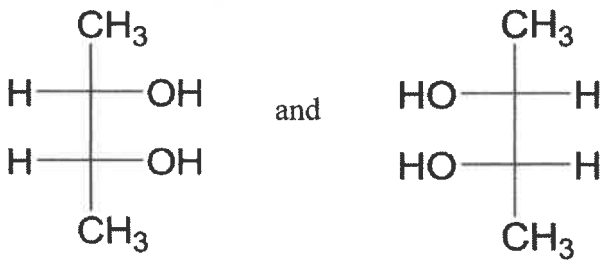
(a)


(b)

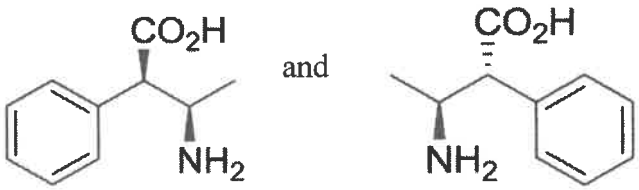

(c)




(d)




(e)




3. Sodium borohydride ($NaBH_4$) reduces only aldehydes and ketones. Lithium aluminum hydride ($LiAlH_4$) will reduce not only aldehydes and ketones but also esters and carboxlic acids. Do you think that sodium hydride (NaH) will also reduce esters and acids? Give a brief explanation for your answer. (10 %)

國立雲林科技大學 107 學年度 碩士班招生考試試題

系所：化材系

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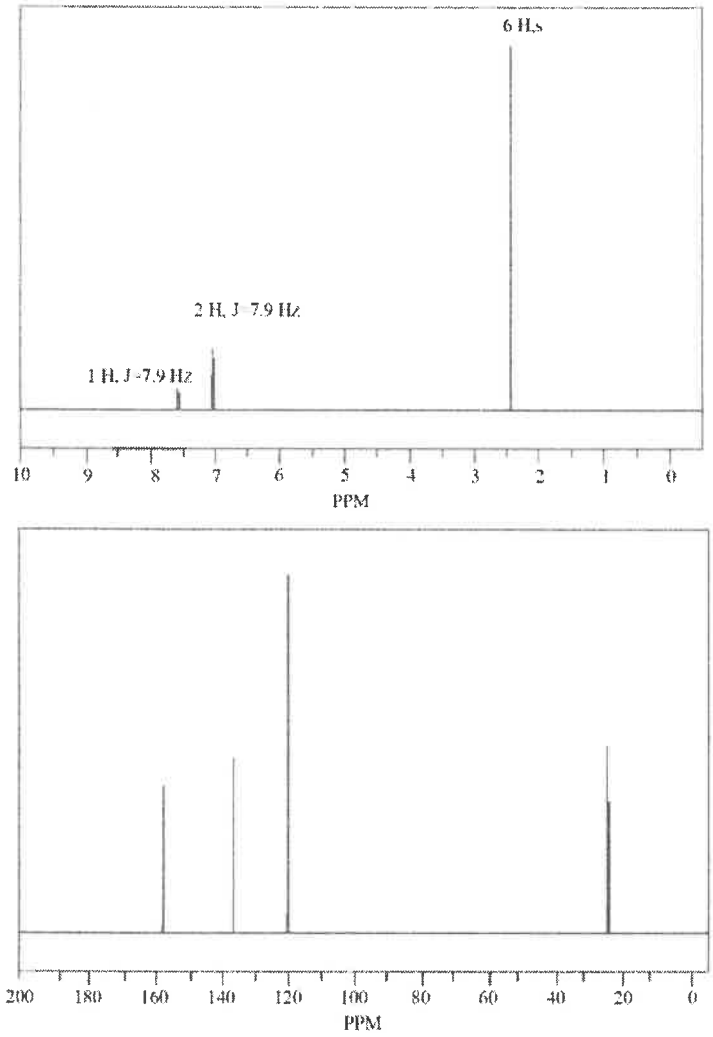
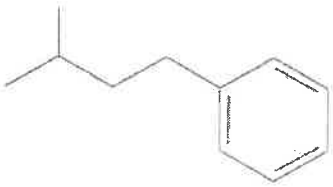
4. An unknown compound has $M_W$ = 107 and shows the following NMR spectra. Draw the structure of the unknown compound. (10%)




5. Starting with benzene and the appropriate acyl chloride or acid anhydride, outline a synthesis of each of the following: (10%)

(a) Butylbenzene

(b)



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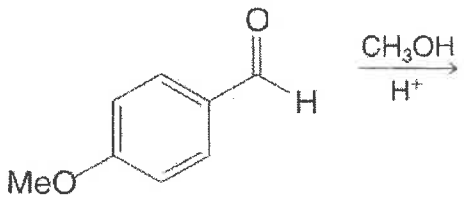
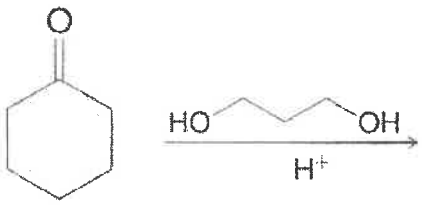
6. Predict the major organic product from each of the following reactions. (10%)

(a)

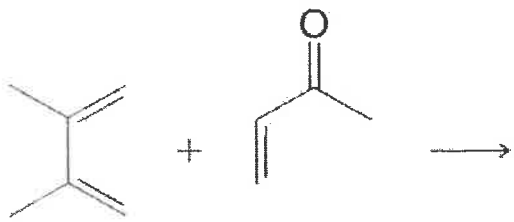



(b)

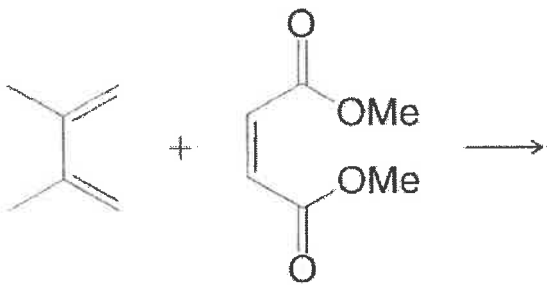



7. What products would you expect from the following reactions? (10%)

(a)




(b)



國立雲林科技大學 107 學年度 碩士班招生考試試題

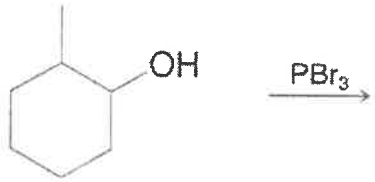
系所：化材系

科目：有機化學

8. Predict the major product from each of the following reactions. (10%)

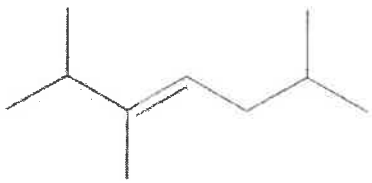
(a)


(b)




9. Give the IUPAC names for each of the following: (10%)

(a)



(b)