國立清華大學 105 學年度碩士班考試入學試題

系所班組別：工程與系統科學系 乙組(0525)

考試科目（代碼）：熱力學 (2502)

 *請在【答案卷】作答

1. (a) Giving a compressibility factor chart, if you are asking to study the ideal gas behavior, please select one of the gases from the following figure 1. (2%)

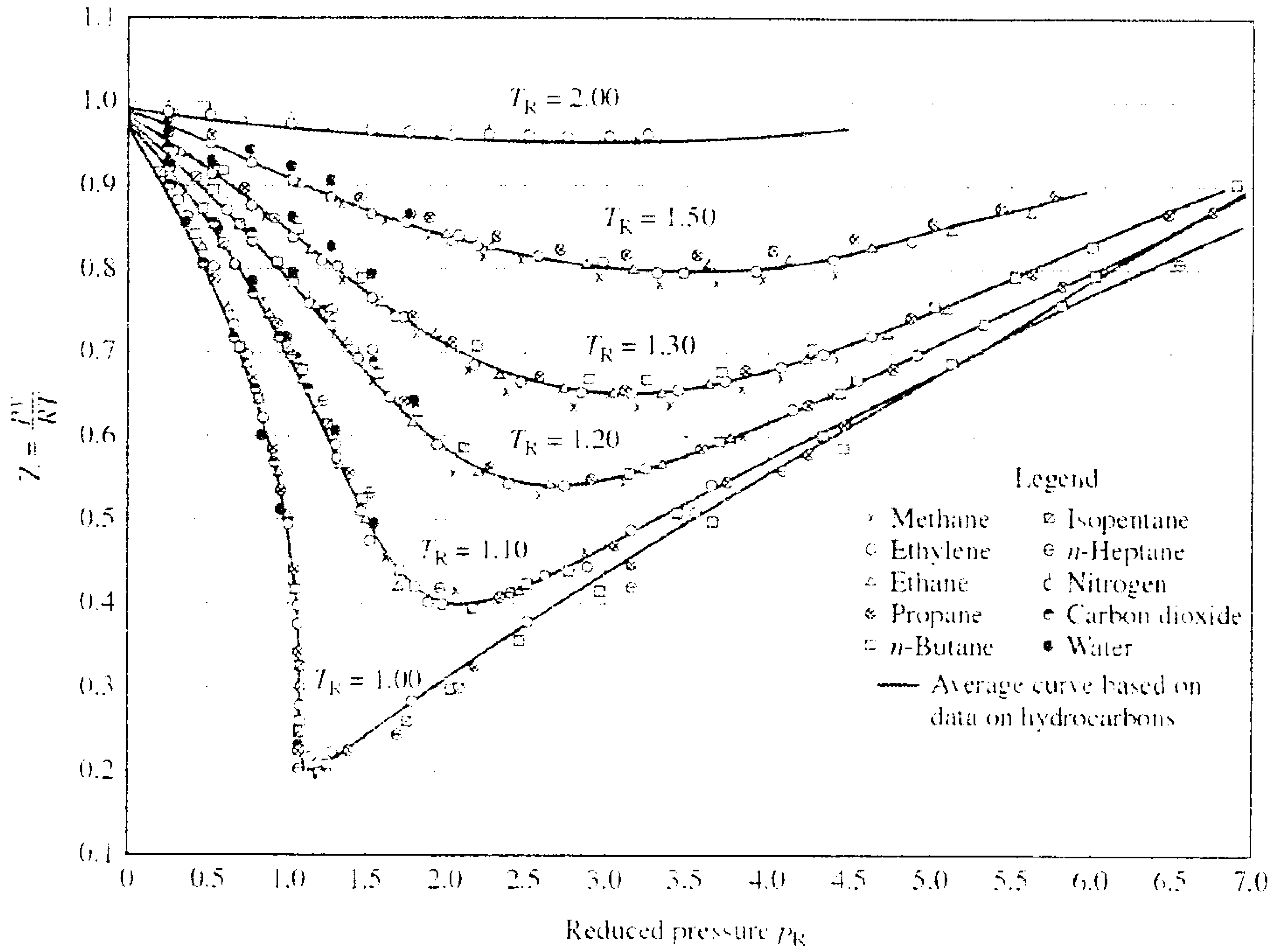

Fig.1 Compressibility factor chart for different gas

(b) Select the right answer for turbine (I) W>0; P_e<P_i (II) W<0; P_e<P_i (III) W>0; P_e>P_i (IV) W<0; P_e>P_i (2%)

(c) Select the right answer for Compressor (I) W>0; P_e<P_i (II) W<0; P_e<P_i (III) W>0; P_e>P_i (IV) W<0; P_e>P_i (2%)

(d) Select the right answer for pump (I) W>0; P_e<P_i (II) W<0; P_e<P_i (III) W>0; P_e>P_i (IV) W<0; P_e>P_i (2%)

(e) Is pump working for liquid or gas? (1%) how about the compressor? (1%)

(f) Giving the definition of Nozzle from the cross section area (1%) and exit velocity view (1%), and what is the definition of Diffuser from the cross section area (1%) and exit velocity view (1%)

(g) When throttling process happens, which thermal properties can be assumed to be equal (kinetic energy and potential energy are neglected) (2%)
(I) U (II) H (III) S (IV) T (V) P (VI) specific volume

(h) For reversible heat engine, $\oint(\frac{\delta Q}{T})_{rev}$ (=0, >0, <0)? (2%) and how about

$\oint \delta Q_{rev}$ (≥ 0, $or \leq 0$) (2%)

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2. (a) What is isentropic process (1%) and gives the requirement for the isentropic (2%)
   (b) What is the Clausius statement of the second law (2%)
   (c) What is the Kelvin-Planck statement of the second law (2%)
   (d) Write down *Clausius* Inequality equation (2%)
   (e) Explain what is the dew point? (1%)
   (f) Giving following figures 2(a) and 2(b), Please answer which one is Heat engine (1%) and which one is Refrigerator (1%)
   (g)The relation between $|Q_H|$, $|Q_C|$ and $|W_{cycle}|$ in Fig. 2(a) (2%) and Fig. 2(b) (2%)
   (h)Which one is the schematic diagram of heat pump, Fig. 2(a) or Fig. 2(b) (1%)
   (i) Given the C.O.P (β) in terms of $|Q_H|$ or $|Q_C|$ and $|W_{cycle}|$ from the Refrigerator (1%), C.O.P (γ) in terms of $|Q_H|$ or $|Q_C|$ and $|W_{cycle}|$ from the Heat pump (1%)
   (j) If heat engine is Carnot engine, what is the cycle efficiency in terms of T_H and T_C (1%)

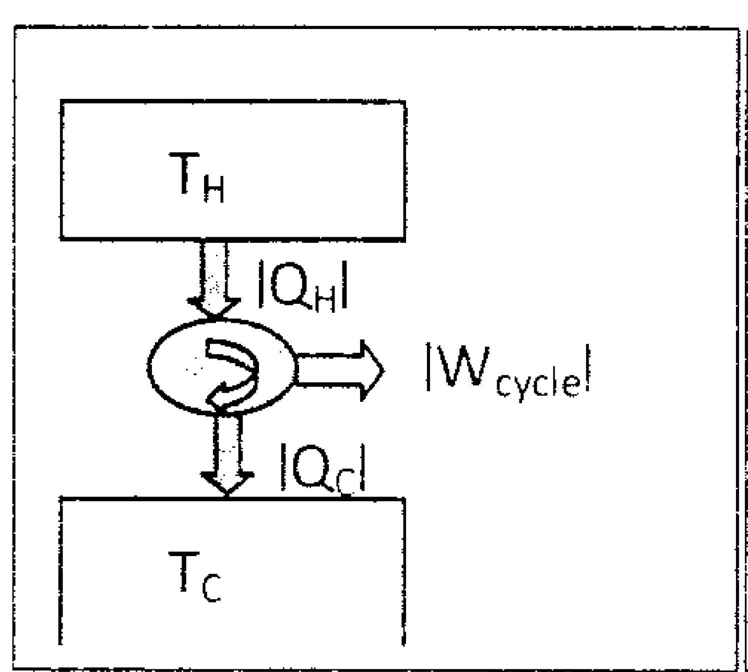

Fig. 2(a)

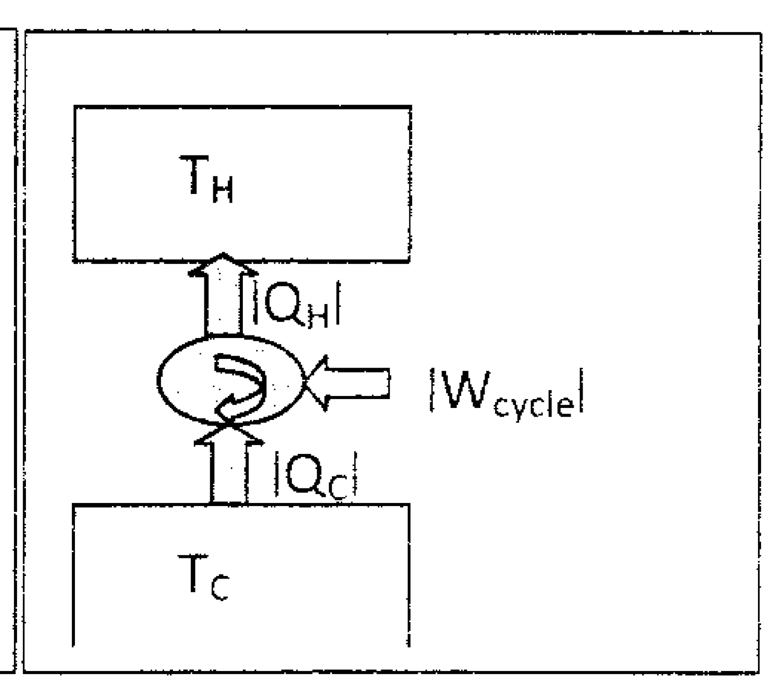

Fig. 2(b)

3. (a) The differential of pressure obtained from a certain equation of state is given as the following. Write down the equation of state. (10%)

$$dp = \left(\frac{R}{V-b} - \frac{a}{V^3}\right)dT + \left[\frac{-RT}{(V-b)^2} + \frac{3aT}{V^4}\right]dV$$

   (b) According to the state of equation from problem (1), please prove internal energy change du is temperature function only. (10%)

4. A power cycle operating between two reservoirs receive energy Q_H by heat transfer from a hot reservoir at T_H=2000K and rejects energy Q_C by heat transfer to a cold reservoir at T_C=400K. For each of the following cases determine whether the cycle operates reversibly, irreversibly, or is impossible:
   (a) Q_H=1000KJ, Q_C =200KJ (4%)
   (b) Q_H=1100KJ, W_{cycle}=900KJ (4%)
   (c) W_{cycle}=1400KJ, Q_C =600KJ (4%)
   (d) η_{th}=85% (4%)
   (e) η_{th}=50% (4%)

5. Water is compressed from state (1) to state (5). Show as in following figure. Assume the specific volume of water v_f and its volume expansivity α_p are constant. Water in liquid phase is following the state equation P=AlnT at constant volume process, where A is constant, and the steam in vapor phase is following the state equation: $P(V-b)=RT$, where b is constant, V is the volume of the fluid. The specific heat of water $C_{(f)}$ is constant, the heat capacity of steam at constant pressure $C_{p(v)}$ and heat capacity at constant volume $C_{v(v)}$ are constant too; Given the saturated liquid enthalpy $\mathbf{h_{f,3}}$ at state (**3**), and the saturated vapor enthalpy $\mathbf{h_{g,3}}$ at state (**3'**), $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_5}$. are the isobaric lines, $\mathbf{T_4=T_5}$, $\mathbf{T_3=T_{3'}}$, Define:
   Volume expansivity is constant: $\alpha_p=\frac{1}{V_f}\left(\frac{\partial V_f}{\partial T}\right)_p$,
   Isothermal compressibility: $\beta_T=-\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$
   (a) Please evaluate and deduce enthalpy change $\mathbf{\Delta h_{12'}}$ as function of $\mathbf{C_{(f)}}$ $\mathbf{T_1}$, $\mathbf{T_{2'}}$ (1%)
   (b) Evaluate enthalpy change $\mathbf{\Delta h_{2'2}}$ (3%) as function of $\mathbf{C_{(f)}}$, $\mathbf{T_2}$, $\mathbf{T_{2'}}$, $\mathbf{P_2}$, $\mathbf{P_{2'}}$, $\mathbf{\alpha_p}$, $\mathbf{V_{f2}}$ and **A** , where $\mathbf{V_{f2}}$ represent the volume of water at state 2.
   (c) Evaluate the internal energy change $\mathbf{\Delta u_{2'2}}$ (1%) from state **2'** to state **2** with function of $\mathbf{C_{(f)}}$, ($\mathbf{T_{2'}}$, $\mathbf{T_2}$)
   (d) Try to derive the entropy change $\mathbf{\Delta S_{2'2}}$ from (T, V) and evaluate $\mathbf{\Delta S_{2'2}}$ as function of $\mathbf{C_{(f)}}$, $\mathbf{T_2}$, $\mathbf{T_{2'}}$ (2%).
   (e) Try to derive the entropy change $\mathbf{\Delta S_{2'2}}$ from (T, P) and evaluate $\mathbf{\Delta S_{2'2}}$ as function of $\mathbf{C_{(f)}}$, $\mathbf{T_2}$, $\mathbf{T_{2'}}$, $\mathbf{\alpha_p}$, $\mathbf{V_{f2}}$. $\mathbf{P_{2'}}$ and $\mathbf{P_2}$ (2%).
   (f) Compare solution of (d) and (e), why makes these two answers are different, explain (2%)

(g) Evaluate the enthalpy change $\Delta h_{33'}$ (1%) and entropy change $\Delta S_{33'}$ (1%) from state (**3**) to state (**3'**) with function of $h_{f,3}$, $h_{g,3}$, and T_3

(h) Evaluate the enthalpy change $\Delta h_{3'4}$ from state (**3'**) to state (**4**) as function of $C_{p(v)}$, $T_{3'}$ and T_4. (1%)

(i) the entropy change $\Delta S_{3'4}$ from state (**3'**) to state (**4**) as function of $C_{v(v)}$, $T_{3'}$, T_4, $V_{3'}$, b, R and V_4. (2%)

(j) Evaluate the enthalpy change and the entropy change Δh_{45} (2%) and ΔS_{45} (2%) from state (**4**) to state (**5**) with function of R, b, P_4 and P_5.