

**INSTRUCTION:**

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

**ARAHAN:**

*Bahagian ini mengandungi EMPAT (4) soalan berstruktur. Jawab SEMUA soalan.*

**QUESTION 1****SOALAN 1**CLO1  
C1

(a) Define the following:

*Definisikan yang berikut:*

i. Boundary

*Sempadan*

[1 marks]

*[1 markah]*

ii. Surrounding

*Keliling*

[1 marks]

*[1 markah]*

iii. System

*Sistem*

[1 marks]

*[1 markah]*

iv. First law of thermodynamics

*Hukum pertama termodinamik*

[2 marks]

*[2 markah]*

CLO2  
C2

(b) Convert the following thermodynamics units:

*Tukarkan unit-unit termodinamik berikut:*

- i. 27 bar to kPa  
*27 bar kepada kPa*

[2 marks]

*[2 markah]*

- ii. 345 m/s to km/hr  
*345 m/s kepada km/hr*

[3 marks]

*[3 markah]*

- iii. 48 mg/liter to kg/m<sup>3</sup>  
*48 mg/liter kepada kg/m<sup>3</sup>*

[3 marks]

*[3 markah]*

- iv. 16 N/cm<sup>2</sup> to kN/m<sup>2</sup>  
*16 N/cm<sup>2</sup> kepada kN/m<sup>2</sup>*

[3 marks]

*[3 markah]*

CLO2  
C3

- (c)  $2.1 \text{ m}^3$  of air at 7.5 bar pressure and  $110 \text{ }^\circ\text{C}$  temperature is cooled at a constant pressure process until the temperature drop at  $45 \text{ }^\circ\text{C}$ . Given  $R = 0.287 \text{ kJ/kg.K}$  and  $C_p = 1.005 \text{ kJ/kg.K}$ .

Calculate:

*2.1 m<sup>3</sup> udara pada tekanan 7.5 bar dan suhu 110 °C disejukkan secara tekanan tetap sehingga suhu menurun kepada 45 °C. Diberi R= 0.287 kJ/kg.K dan C<sub>p</sub>= 1.005kJ/kg.K. Kirakan:*

- i. mass of air  
*jisim udara*

[3 marks]

[3 markah]

- ii. heat rejected in the process  
*haba yang dibebaskan semasa proses*

[3 marks]

[3 markah]

- iii. volume of the air after cooling  
*isipadu udara selepas disejukkan*

[3 marks]

[3 markah]

## QUESTION 2

## SOALAN 2

CLO2  
C1

(a) Define

*Takrifkan*

i. Flow Process

*Proses Aliran Sekata*

[3 marks]

[3 markah]

ii. Steady Flow Process

*Proses Aliran Mantap*

[3 marks]

[3 markah]

iii. Non Steady Flow Process

*Proses Aliran Tak Mantap*

[3 marks]

[3 markah]

CLO2  
C2

(b) In an air conditioning system, air is cooled by passing it over a chilled water coil condenser. Water enters the coil with an enthalpy of 42kJ/kg and leaves the coil with an enthalpy of 80kJ/kg. The water flow rate is 200 kg/h. Determine the rate of heat absorption of the water in **kilowatts**.

*Dalam sistem penyaman udara, udara disejukkan dengan melepasi kondenser gegelung air sejuk. Air memasuki gegelung dengan entalpi 42kJ / kg dan meninggalkan gegelung dengan entalpi 80kJ / kg. Kadar aliran air adalah 200 kg / h. Tentukan kadar penyerapan haba oleh air dalam **kilowatt**.*

[7 marks]

[7 markah]

CLO2  
C3

- (c) Steam steadily enters the turbine at 4600 kg / hour and produces a power output of 1000 kJ/kg.

Steam at the entrance is as followed:

Flow velocity 250 m/s, 8.5 bar pressure, energy in 2300 kJ/kg and specific volume  $0.55 \text{ m}^3/\text{kg}$

Steam on the exit is as followed:

Flow velocity 125 m/s, 2.3 bar pressure, energy in 1700 kJ/kg and specific volume of  $1.75 \text{ m}^3 / \text{kg}$ .

Calculate the value of the heat transferred to the environment if the energy is small and negligible.

*Stim mengalir secara mantap memasuki turbin dengan kadar 4600 kg/jam dan menghasilkan kuasa keluaran sebanyak 1000 kJ/kg.*

*Stim pada bahagian masuk berkeadaan seperti berikut:*

*Halaju aliran 250 m/s, tekanan 8.5 bar, tenaga dalam 2300 kJ/kg dan isipadu tentu  $0.55 \text{ m}^3/\text{kg}$*

*Stim pada bahagian keluar pula berkeadaan seperti berikut:*

*Halaju aliran 125 m/s, tekanan 2.3 bar, tenaga dalam 1700 kJ/kg dan isipadu tentu  $1.75 \text{ m}^3/\text{kg}$ .*

*Hitungkan nilai haba yang dipindahkan ke sekitaran sekiranya tenaga keupayaan kecil dan boleh diabaikan.*

[9 marks]

[9 markah]

**QUESTION 3****SOALAN 3**CLO1  
C1

(a) Define the following terms:

*Definisikan terma-terma berikut:*

i. Enthalpy

*Entalpi*

[1 marks]

*[1 markah]*

ii. Solid phase

*Fasa pepejal*

[2 marks]

*[2 markah]*

iii. Liquid phase

*Fasa cecair*

[2 marks]

*[2 markah]*

CLO2  
C2

- (b) Consider a steam power plant operating on the ideal Rankine Cycle. Superheated steam enters the turbine at 35 bar and 500 °C and exits the condenser as a saturated liquid at 0.045 bar. The pump work is negligible. Determine:

*Andaikan kendalian loji kuasa stim beroperasi dengan Kitaran Rankine unggul. Stim panas terlampau memasuki sebuah dandang pada tekanan 35 bar serta suhu 500 °C dan keluar melalui kondenser sebagai cecair tepu pada tekanan 0.045 bar. Abaikan kerja yang dilakukan oleh pam. Tentukan:*

- i. The work for turbine

*Kerja untuk turbin*

[10 marks]

[10 markah]

- ii. Thermal efficiency

*Kecekapan terma*

[3 marks]

[3 markah]

CLO2  
C3

- (c) If the steam at pressure of 90 bar and the enthalpy is at 3118 kJ/kg, calculate the specific internal energy for the steam.

*Jika suatu stim berada pada tekanan 90 bar dan entalpinya ialah 3118 kJ/kg, kirakan tenaga dalam spesifik stim tersebut.*

[7 marks]

[7 markah]

## QUESTION 4

## SOALAN 4

CLO2  
C1

- (a) Define Reversible Process and sketch the appropriate P-V diagram to illustrate the process.

*Takrifkan Proses Bolehbalik dan lakarkan rajah P-V yang sesuai untuk menggambarkan proses tersebut.*

[5 marks]

[5 markah]

CLO2  
C2

- (b) A perfect gas undergoes an expand of adiabatic process. The initial state was at 9.5 bar pressure and 0.011 m<sup>3</sup> volume. After the pressure expansion the value of the pressure is 1.05 bar. Given  $C_p = 1.026$  kJ/kgK and  $C_v = 0.747$  kJ/kgK.

Calculate:

*Satu gas sempurna mengalami proses pengembangan secara adiabatic. Keadaan awal gas adalah pada tekanan 9.5 bar dan isipadu 0.011 m<sup>3</sup>. Selepas pengembangan didapati tekanannya bernilai 1.05 bar. Diberi  $C_p = 1.026$  kJ/kgK dan  $C_v = 0.747$  kJ/kgK*

*Hitungkan :*

- i. Final volume  
*Isipadu akhir*

[4 markah]

[4 markah]

- ii. Work done  
*Kerja yang dilakukan*

[3 markah]

[3 markah]

- iii. Change of internal energy  
*Perubahan tenaga dalam*

[3 markah]

[3 markah]

CLO2  
C3

(c) 1 kg of perfect gas at 30°C is in the cylinder. If the heat entering the system is 350 kJ/kg, calculate the entropy change when:

*1 kg gas sempurna pada suhu 30°C berada dalam selinder. Jika haba yang masuk ke dalam system adalah 350 kJ/kg, kirakan perubahan entropy bila:*

i. The process is constant volume

*Proses adalah isipadu tetap*

[5 markah]

[5 markah]

ii. The process is constant pressure

*Process adalah tekanan tetap*

[5 markah]

[5 markah]

Take  $C_p = 1.0 \text{ kJ/kgK}$  and  $C_v = 0.7 \text{ kJ/kgK}$

*Ambil  $C_p = 1.0 \text{ kJ/kgK}$  dan  $C_v = 0.7 \text{ kJ/kgK}$*

**SOALAN TAMAT**

**BASIC THERMODYNAMICS**

$$\begin{aligned} \bullet P_v &= mRT & \bullet R &= C_p - C_v \\ \bullet U_2 - U_1 &= Q - W & \bullet \gamma &= \frac{C_p}{C_v} \\ \bullet \frac{P_1 V_1}{T_1} &= \frac{P_2 V_2}{T_2} \\ \bullet R &= \frac{R_o}{M} \end{aligned}$$

**NON FLOW PROCESS****1. Isothermal Process ( T<sub>1</sub> = T<sub>2</sub> )**

$$\begin{aligned} \bullet U_2 - U_1 &= 0 \\ \bullet Q &= W \\ \bullet W &= P_1 V_1 \ln\left(\frac{V_2}{V_1}\right) \quad @ \quad W = P_1 V_1 \ln\left(\frac{P_1}{P_2}\right) \end{aligned}$$

**2. Adiabatic Process (Seentropi)**

$$\begin{aligned} \bullet U_2 - U_1 &= mC_v(T_2 - T_1) \\ \bullet W &= \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{mR(T_1 - T_2)}{\gamma - 1} \\ \bullet Q &= 0 \end{aligned}$$

$$\bullet \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

**3. Polytropic Process**

$$\begin{aligned} \bullet U_2 - U_1 &= mC_v(T_2 - T_1) \\ \bullet W &= \frac{P_1 V_1 - P_2 V_2}{n-1} = \frac{mR(T_1 - T_2)}{n-1} \\ \bullet Q &= \frac{\gamma-n}{\gamma-1} \times W \end{aligned}$$

$$\bullet \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$$

**4. Constant Pressure Process ( P<sub>1</sub> = P<sub>2</sub> )**

$$\begin{aligned} \bullet Q &= mC_p(T_2 - T_1) \\ \bullet U_2 - U_1 &= Q - W = mC_v(T_2 - T_1) \\ \bullet W &= P(V_2 - V_1) = mR(T_2 - T_1) \end{aligned}$$

**5. Constant Volume Process ( V<sub>1</sub> = V<sub>2</sub> )**

$$\begin{aligned} \bullet Q &= U_2 - U_1 = mC_v(T_2 - T_1) \\ \bullet W &= 0 \end{aligned}$$

**FLOW PROCESS**

$$\begin{aligned} \bullet Q - W &= \dot{m} \left[ (h_2 - h_1) + \left( \frac{C_2^2 - C_1^2}{2000} \right) + \left( \frac{Z_2 - Z_1}{1000} \right) g \right] \\ \bullet h_2 - h_1 &= (U_2 - U_1) + (P_2 v_2 - P_1 v_1) = C_p (T_2 - T_1) \\ \bullet \dot{m} &= \frac{CA}{v} \end{aligned}$$

**PROPERTIES OF STEAM**

$$\begin{aligned} \bullet v &= x(v_g) & \bullet U &= U_f + x(U_g - U_f) \\ \bullet h &= h_f + x(h_{fg}) & \bullet S &= S_f + x(S_{fg}) \\ \bullet h &= U + Pv \end{aligned}$$

**2<sup>nd</sup> LAW THERMODYNAMICS****1. STEAM****a. Constant Pressure Process ( P<sub>1</sub> = P<sub>2</sub> )**

$$\begin{aligned} W &= P(V_2 - V_1) = Q - (u_2 - u_1) \\ Q &= h_2 - h_1 \end{aligned}$$

**b. Constant Volume Process ( V<sub>1</sub> = V<sub>2</sub> )**

$$W = 0 \quad Q = u_2 - u_1$$

**c. Isothermal Process ( T<sub>1</sub> = T<sub>2</sub> )**

$$Q = T(s_2 - s_1) \quad W = Q - (u_2 - u_1)$$

**d. Adiabatic Process (Seentropi)**

$$s_1 = s_2 \quad Q = 0 \quad W = u_1 - u_2$$

**e. Polytropic Process**

$$W = \frac{P_1 V_1 - P_2 V_2}{n-1} \quad Q = (u_2 - u_1) + W$$

**2. PERFECT GAS****a. Constant Pressure Process ( P<sub>1</sub> = P<sub>2</sub> )**

$$\bullet s_2 - s_1 = mC_p \ln\left(\frac{T_2}{T_1}\right)$$

**b. Constant Volume Process ( V<sub>1</sub> = V<sub>2</sub> )**

$$\bullet s_2 - s_1 = mC_v \ln\left(\frac{T_2}{T_1}\right)$$

**c. Isothermal Process ( T<sub>1</sub> = T<sub>2</sub> )**

$$\bullet s_2 - s_1 = mR \ln\left(\frac{v_2}{v_1}\right) = mR \ln\left(\frac{P_1}{P_2}\right)$$

**d. Polytropic Process**

$$\bullet s_2 - s_1 = mR \ln\left(\frac{v_2}{v_1}\right) - mC_v \ln\left(\frac{T_1}{T_2}\right)$$

**Or**

$$\bullet s_2 - s_1 = mR \ln\left(\frac{P_1}{P_2}\right) - mC_p \ln\left(\frac{T_1}{T_2}\right)$$

**POWER CYCLES STEAM**

$$\begin{aligned} \bullet \eta_c &= \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_4)} \\ \bullet r_w &= \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)} \\ \bullet s.s.c. &= \frac{3600}{(h_1 - h_2) - (h_4 - h_3)} \end{aligned}$$

**CHEMICAL EQUILIBRIUM**

$$\begin{aligned} \bullet \Delta S &= Q_p (S_p - S_A) \\ \bullet \Delta G &= \Delta G^0 + RT \ln K \\ \bullet \frac{d(\ln K)}{dT} &= \frac{\Delta H}{RT^2} \end{aligned}$$