SULIT

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENGAJIAN TINGGI

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI II : 2021/2022

DGP20053 : THERMODYNAMICS

TARIKH : 02 JULAI 2022
MASA : 8.30 AM - 10.30 AM (2 JAM)

Kertas ini mengandungi **ENAM (6)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula / Buku Jadual Stim

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JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

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) Describe the Boyle's Law and Charles' Law of a perfect gas

Terangkan Hukum Boyle dan Hukum Charles bagi suatu gas sempurna

[6 marks]

[6 markah]

CLO1 C2

(b) Given P = 17 bar and T= 300^{0}C . By referring to the steam table, interpolate:

Diberi P = 17 bar dan T= 300^{o}C. merujuk kepada jadual stim, interpolasikan:

i. degree of superheated steam.

tahap suhu stim panas lampau.

[5 marks]

[5 markah]

ii. specific enthalpy

entalpi tentu

[4 marks]

[4 markah]

CLO1 C3

(c) A perfect gas is contained in a rigid vessel at 3 bar and 315 °C. The gas is then cooled until the pressure falls to 1.5 bar. Given:M = 26 and γ = 1.26. Calculate the heat rejected per kg of gas.

Suatu gas sempurna terkandung dalam sebuah bekas tegar pada 3 bar dan 315 °C. Gas ini kemudiannya disejukkan sehingga tekanan jatuh ke 1.5 bar. Diberi: M = 26 dan γ = 1,26. Hitungkan haba yang disingkirkan per kg gas.

[10 marks]

[10 markah]

QUESTION 2
SOALAN 2

CLO1
C2

(a) A mass of 0.18 kg gas is at the temperature of 15°C, volume 0.17 m^3 and pressure 130 kN/m^2. If the gas has a value of $C_v = 0.720$ kJ/kg K, simplify:
Satu jisim 0.18 kg gas pada suhu 15°C, isipadu 0,17 m^3 dan tekanan 130 kN/m^2. Jika gas mempunyai nilai Cv =0.720kJ/kg K, permudahkan:

i. Gas constant and Molecular Weight
Pemalar gas dan Berat Molekul

[6 marks]
[6 markah]

ii. Specific heat at constant pressure and Specific heat ratio
Haba tentu pada tekanan tetap dan Nisbah haba tentu

[4 marks]
[4 markah]

CLO1
C3

(b) A rigid insulated container contains 3kg of an ideal gas. The gas is stirred so that its state changes from 6kPa and 250K to 13kPa. Assuming C_p = 1 kJ/kg K and γ= 1.4, calculate t:
Sebuah bekas bertebat tegar memengandungi 3kg gas ideal. Gas dikacau supaya keadaannya berubah dari 6kPa dan 250K kepada 13kPa. Dengan mengandaikan C_p = 1 kJ / kg K dan γ= 1.4, kirakan:

i. Rejected heat
Haba yang disingkirkan

[11 marks]
[11 markah]

ii. Change of the entropy of the system.
Perubahan entropi sistem tersebut.

[4 marks]
[4 markah]

QUESTION 3

SOALAN 3

CLO1
C1

(a) State **FOUR (4)** assumptions for the steady state energy equation.

Nyatakan EMPAT (4) andaian terhadap persamaan tenaga aliran mantap.

[4 marks]

[4 markah]

CLO1
C2

(b) Relate the assumptions made for the following equipment when the steady state energy equation is applied:

Kaitkan andaian yang dibuat terhadap peralatan berikut apabila persamaan tenaga keadaan mantap diaplikasikan:

i. Boiler

Dandang

[5 marks]

[5 markah]

ii. Pump

Pam

[5 marks]

[5 markah]

CLO1
C3

(c) An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2 m^2 opening with an average velocity of 40 m/s, and exhausts through a 1m^2 opening. Calculate the work output by the turbine in kW. Given : R = 0.287kJ/kg.K Cp= 1.048 kJ/kg.K

Suatu turbin gas adiabatik mengembang udara pada 1300 kPa dan 500°C kepada 100 kPa dan 127°C. Udara memasuki turbin melalui bukaan 0.2 m^2 dengan kelajuan purata 40 m/ s, dan ekzos melalui bukaan 1m^2. Kirakan kerja keluaran oleh turbin di dalam kW. Diberi: R = 0.287kJ/kg.K Cp = 1.048 kJ/kg.K

[11 marks]

[11 markah]

QUESTION 4

SOALAN 4

CLO1
C2

(a) A steam power plant operates on a Rankine cycle without superheat. The steam is in the dry saturated vapour state as it enters the turbine. Simlify the ideal cycle efficiency if the boiler pressure is 1 MPa and the condensing pressure is 0.002Mpa

Sebuah loji kuasa stim beroperasi pada kitaran Rinkine tanpa wap panas lampau. Stim adalah dalam keadaan wap tepu kering ketika ia memasuki turbin. Permudahkan kecekapan kitaran ideal jika tekanan dandang adalah 1 MPa dan tekanan terkondensasi adalah 0.002Mpa

[15 marks]

[*15 markah*]

CLO1
C3

(b) Calculate ΔH and ΔS for the following reaction and decide in which direction each of these factors will drive the reaction.

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Using a standard-state enthalpy of formation and absolute entropy data below:

Compound	**ΔH_f^o(kJ/mol)**	**S (J/mol-K)**
$N_2(g)$	**0**	**191.61**
$H_2(g)$	**0**	**130.68**
$NH_3(g)$	**-46.11**	**192.45**

Use the values of H and S to predict whether the following reaction is spontaneous at 25°C:

Kirakan nilai ΔH dan ΔS bagi tindak balas berikut serta tentukan arah manakah faktor ini mendorong tindak balas.

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Gunakan data pembentukan piawaian entalpi dan entropi mutlak di bawah:

Sebatian	ΔH_f^0(kJ/mol)	S (J/mol-K)
$N_2(g)$	0	191.61
$H_2(g)$	0	130.68
$NH_3(g)$	-46.11	192.45

Gunakan nilai ΔH dan ΔS yang diperolehi untuk meramalkan sama ada tindak balas berikut adalah spontan pada 25°C.

[10 marks]

[10 markah]

SOALAN TAMAT

LIST OF FORMULAS DGP20053 THERMODYNAMICS

PROPERTIES OF SUBSTANCES

1. **STEAM**

$$v = xv_g \qquad u = u_f + x(u_g - u_f)$$

$$h = h_f + xh_{fg} \qquad s = s_f + xs_{fg}$$

$$h = u + Pv$$

2. **IDEAL GAS**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad R = \frac{R_o}{M} \qquad \gamma = \frac{C_P}{C_V}$$

$$PV = mRT \qquad R = C_p - C_v \qquad m = nM$$

$$C_v = \frac{R}{(\gamma - 1)} \qquad C_p = \frac{\gamma R}{(\gamma - 1)}$$

1ST LAW OF THERMODYNAMICS

1. **NON-FLOW PROCESS : REVERSIBLE PROCESS STEAM**

CONSTANT ISOTHERMAL PROCESS ($T_1 = T_2$)	$Q = T(s_2 - s_1)$ $\quad W = Q - (u_2 - u_1)$
CONSTANT VOLUME PROCESS ($V_1 = V_2$)	$Q = (u_2 - u_1)$ $\quad W = 0$
CONSTANT PRESSURE PROCESS ($P_1 = P_2$)	$Q = (u_2 - u_1) + P(v_2 - v_1)$ $\quad Q = h_2 - h_1$ $Q = (u_2 + Pv_2) - (u_1 + Pv_1)$ $\quad W = P(v_2 - v_1)$
ADIABATIC (ISENTROPIC) PROCESS	$S_1 = S_2$ $\quad Q = 0$ $\quad W = u_1 - u_2$
POLYTROPIC PROCESS	$W = \frac{p_1v_1 - p_2v_2}{n-1}$ $\quad \frac{p_1}{p_2} = \left(\frac{v_2}{v_1}\right)^n$; $\frac{v_2}{v_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{n}}$ $Q = (u_2 * u_1) + W$ $\quad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$; $\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{n-1}$

2. NON-FLOW PROCESS: REVERSIBLE PROCESS FOR IDEAL GAS

CONSTANT ISOTHERMAL PROCESS ($T_1 = T_2$)	$W = p_1 V_1 \ln\frac{V_2}{V_1}$ $W = p_1 V_1 \ln\frac{p_1}{p_2}$ $W = mRT_1 \ln\frac{V_2}{V_1}$ $W = mRT_1 \ln\frac{p_1}{p_2}$ $Q = W$ $U_1 = U_2$ $S_2 - S_1 = mR\ln\left(\frac{v_2}{v_1}\right) = mR\ln\left(\frac{p_1}{p_2}\right)$
CONSTANT VOLUME PROCESS ($V_1 = V_2$)	$W = 0$ $Q = mC_v(T_2 - T_1)$ $Q = U_2 - U_1$ $S_2 - S_1 = mC_v \ln\left(\frac{T_2}{T_1}\right)$
CONSTANT PRESSURE PROCESS ($P_1 = P_2$)	$W = p(V_2 - V_1)$ $W = mR(T_2 - T_1)$ $Q = mC_p(T_2 - T_1)$ $U_2 - U_1 = Q - W$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $S_2 - S_1 = mC_p \ln\left(\frac{T_2}{T_1}\right)$
ADIABATIC (ISENTROPIC)PROCESS	$W = \frac{p_1V_1 - p_2V_2}{\gamma - 1}$ $W = \frac{mR(T_1 - T_2)}{\gamma - 1}$ $W = mC_v(T_1 - T_2)$ $Q = 0$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $S_2 - S_1 = 0$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{\gamma-1}{\gamma}} = \left[\frac{V_1}{V_2}\right]^{\gamma-1}$
POLYTROPIC PROCESS	$S_2 - S_1 = R\ln\left(\frac{v_2}{v_1}\right) - C_v \ln\left(\frac{T_1}{T_2}\right)$ $S_2 - S_1 = mR\ln\left(\frac{p_1}{p_2}\right) - mC_p \ln\left(\frac{T_1}{T_2}\right)$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} = \left[\frac{V_1}{V_2}\right]^{n-1}$

	$U_2 - U_1 = mC_v(T_2 - T_1)$ $W = \dfrac{P_1V_1 - P_2V_2}{n-1}$ $Q = W + U_2 - U_1$ $W = \dfrac{mR(T_1 - T_2)}{n-1}$

3. **FLOW PROCESS**

STEADY FLOW ENERGY EQUATION

- $Q - W = \dot{m}\left[(h_2 - h_1) + \left(\frac{C_2^2 - C_1^2}{2}\right) + g(Z_2 - Z_1)\right]$
- $h_2 - h_1 = (U_2 - U_1) + (P_2v_2 - P_1v_1) = C_p(T_2 - T_1)$
- $\dot{m} = \frac{CA}{v}$

2ND LAW OF THERMODYNAMICS

HEAT ENGINE / PUMP ENGINE

$$W = Q_1 - Q_2 \qquad \eta = \frac{W}{Q_1}$$

CARNOT CYCLE ENGINE

$$\eta = 1 - \frac{Q_2}{Q_1} \qquad \eta_{carnot} = 1 - \frac{T_2}{T_1}$$

$$\eta_{Carnot} = \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4}$$

$$r_w = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)}$$

$$s.s.c. = \frac{3600}{(h_1 - h_2) - (h_4 - h_3)} \text{ kg/kwh}$$

CHEMICAL EQUILLIBRIUM

$$\Delta S = Q_p (S_P - S_A)$$

$$\Delta G = \Delta G^O + RT \ln K$$

$$\frac{d(\ln K)}{dT} = \frac{\Delta H}{RT^2}$$