SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

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

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI II : 2022/2023

DGP20053 : THERMODYNAMICS

TARIKH : 7 JUN 2023
MASA : 2.30 PTG - 4.30 PTG (2 JAM)

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

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula

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 (a) Define

Definasikan

i. intensive properties

sifat intensif

[2 marks]
[*2 markah*]

ii. extensive properties

sifat ekstensif

[2marks]
[*2 markah*]

CLO1 (b) A mass of air has an initial pressure of 1.3 MN/m^2, volume $0.014m^3$ and temperature 135°C. It is expanded until its final pressure is $275kN/m^2$ and its volume becomes $0.056m^3$. Calculate:

Take R = 0.287kJ/kgK

Jisim udara mempunyai tekanan awal sebanyak 1.3 MN/m^2, isipadu $0.014m^3$ dan suhu 135°C. Ia berkembang sehingga tekanan akhir $275kN/m^2$ dan isipadu akhir $0.056m^3$. Kirakan:

Ambil R = 0.287kJ/kgK

i. The mass of air.

Jisim udara.

[5 marks]
[*5 markah*]

ii. The final temperature

Suhu akhir

[4 marks]
[*4 markah*]

CLO1 (c) Use steam tables to determine the specific enthalpy (h), the specific internal energy (u) and the specific volume (v) when given superheated steam at 6 bar and 260°C

Gunakan jadual stim untuk menentukan entalpi tentu (h), tenaga dalaman tentu (u) dan isipadu tentu (v) apabila diberi keadaan stim panas lampau pada 6 bar dan 260°C

[12 marks]
[*12 markah*]

QUESTION 2
SOALAN 2

CLO1 (a) A quantity of gas expands isothermally from an initial pressure of 5 bar and an initial volume of $0.2m^3$ to a final volume of $0.9m^3$. Calculate:
Suatu kuantiti gas mengembang sesuhu dari tekanan awal 5 bar dan isipadu awal $0.2m^3$ kepada isipadu akhir $0.9m^3$. Kirakan:

i. The final pressure
Tekanan akhir

[3 marks]
[*3 markah*]

ii. The work done
Kerja yang dilakukan

[3 marks]
[*3 markah*]

CLO1 (b) Heat energy is added to the gas in a closed cylinder. Due to this, the volume increased from 0.128 m^3 to $0.96m^3$ at constant pressure $800KN/m^2$. If the molecular weight of gas is 28 and the initial temperature was 35°C, calculate:
Take $C_v = 0.717kJ/kgK$ and $R_o = 8.314kJ/kgK$
Tenaga haba ditambahkan kepada gas di dalam sebuah selinder tertutup. Disebabkan ini, isipadunya bertambah dari 0.128 m^3 kepada $0.96m^3$ pada tekanan tetap $800kN/m^2$. Jika berat molekul gas itu ialah 28 dan suhu awalnya 35°C, hitungkan:
Ambil $C_v = 0.717kJ/kgK$ dan $R_o = 8.314kJ/kgK$

i. The mass of the gas and heat transfer.
Jisim gas dan pemindahan haba.

[13 marks]
[*13 markah*]

ii. Work produced and change of internal energy
Kerja yang dihasilkan dan perubahan tenaga dalam

[6 marks]
[*6 markah*]

QUESTION 3
SOALAN 3

CLO1 (a) Define:
Takrifkan:

i. First Law of Thermodynamics
Hukum Termodinamik Pertama

[3marks]
[*3 markah*]

ii. The Principle of Conservation of Energy.

Prinsip Keabadian Tenaga.

[3 marks]
[*3 markah*]

CLO1 (b) 0.05 kg of nitrogen (M = 28) contained in a cylinder behind a piston is initially at 3.8 bar and 140 °C. The gas expands isothermally and reversibly to a pressure of 1.01 bar. Assuming nitrogen to act as a perfect gas, calculate the change of entropy and heat flow.
0.05 kg nitrogen (M = 28) yang terkandung dalam silinder di belakang piston pada 3.8 bar dan 140 °C pada mulanya. Gas mengembang secara isotermal dan berbalik kepada tekanan 1.01 bar. Dengan mengandaikan nitrogen bertindak sebagai gas yang sempurna, kirakan perubahan entropi dan aliran haba.

[11 marks]
[*11 markah*]

CLO1 (c) Air enters a horizontal nozzle at a pressure of 3.2 bar, a temperature of 230°C, and a velocity of 135 m/s. The air expands adiabatically and reversibly (i.e. without friction) in the nozzle, leaving the nozzle with an exit pressure of 1 bar. Calculate the air temperature and the air velocity at the nozzle exit.

Take R = 287 J/kg K, $\gamma = 1.4$, $C_p = 1.005$kJ/kg.K

Udara memasuki muncung yang mendatar pada tekanan 3.2 bar, suhu 230°C dan halaju 135 m/ s. Udara mengembang secara adiabatik dan boleh balik (iaitu tanpa geseran) dalam muncung, meninggalkan muncung dengan tekanan keluar 1 bar. Kira suhu udara dan halaju udara di pintu keluar muncung.

Ambil R = 287 J / kg K, $\gamma = 1.4$, $C_p = 1.005$kJ / kg.K

[8 marks]

[*8 markah*]

QUESTION 4

SOALAN 4

CLO1 (a) A steam power plant operates using a wet steam. The work done from turbine is 970 kJ/kg and work needed from pump is 4.5 kJ/kg. The pressure for a boiler is 40 bar. Approximate the pressure of condenser, the quality of steam and work ratio for Rankine cycle.

Loji janakuasa stim beroperasi menggunakan stim basah. Kerja yang terhasil daripada turbin adalah 970kJ/kg dan kerja yang diperlukan daripada pam adalah 4.5 kJ/kg. Tekanan pada dandang adalah 40 bar. Anggarkan tekanan pemeluwapan, kualiti stim dan nisbah kerja untuk kitaran Rankine.

[15 marks]

[*15 markah*]

CLO1

(b) $CH_4\,(g) + O_2\,(g) \rightarrow CO_2\,(g) + H_2O\,(g)$

By considering the following reaction above, and from thermodynamic data given in Table 4(b), the value of the standard free energy of formation $\Delta G°_f$ is as follows:

Dengan mempertimbangkan tindak balas di atas, dan daripada data termodinamik yang diberikan dalam Jadual 4(b), nilai tenaga bebas pembentukan $\Delta G°_f$ adalah seperti berikut:

Table 4(b) / *Jadual 4(b)*

Composition *Komposisi*	$\Delta G°_f$ kJ/mol At 298.15K
CH_4	–50.72
CO_2	-394.4
H_2O	-228.6

i. Balance the chemical equation given.
Imbangkan persamaan kimia yang diberikan.

[2 marks]
[*2 markah*]

ii. Calculate the standard Gibbs free energy change for the reaction given.
Kirakan perubahan tenaga bebas Gibbs bagi tindakbalas yang diberikan.

[6 marks]
[*6 markah*]

iii. State whether the reaction is spontaneous or not
Nyatakan sama ada tindakbalas adalah spontan atau tidak.

[2 marks]
[*2 markah*]

SOALAN TAMAT

LIST OF FORMULAS DGP20053 THERMODYNAMICS

PROPERTIES OF SUBSTANCES

1. **STEAM**

$v = xv_g$	$u = u_f + x(u_g - u_f)$
$h = h_f + xh_{fg}$	$s = s_f + xs_{fg}$
$h = u + Pv$	

2. **IDEAL GAS**

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	$R = \frac{R_o}{M}$	$\gamma = \frac{C_P}{C_V}$
$PV = mRT$	$R = C_p - C_v$	m = nM
$C_v = \frac{R}{(\gamma - 1)}$	$C_p = \frac{\gamma R}{(\gamma - 1)}$	

1ST LAW OF THERMODYNAMICS

1. NON-FLOW PROCESS : REVERSIBLE PROCESS FOR 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	$W = \frac{p_1v_1 - p_2v_2}{n-1}$ $\quad Q = (u_2 - u_1) + W$ $\frac{p_1}{p_2} = \left(\frac{v_2}{v_1}\right)^n$; $\frac{v_2}{v_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{n}}$ $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$; $\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{n-1}$

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

CONSTANT ISOTHERMAL PROCESS ($T_1 = T_2$)	$W = p_1V_1 \ln\frac{V_2}{V_1}$ $\quad W = p_1V_1 \ln\frac{p_1}{p_2}$ $W = mRT_1 \ln\frac{V_2}{V_1}$ $\quad W = mRT_1 \ln\frac{P_1}{P_2}$ $Q = W$ $\quad U_1 = U_2$ $S_2 - S_1 = mR\ln\left(\frac{v_2}{v_1}\right) = mR\ln\left(\frac{p_1}{p_2}\right)$
CONSTANT VOLUME PROCESS ($V_1 = V$)	$W = 0$ $\quad Q = mC_v(T_2 - T_1)$ $Q = U_2 - U_1$ $S_2 - S_1 = mC_v \ln\left(\frac{T_2}{T_1}\right)$

LAMPIRAN : FORMULA DGP20053 THERMODYNAMICS

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	$S_2 - S_1 = R\ln\left(\frac{v_2}{v_1}\right) - C_v \ln\left(\frac{T_1}{T_2}\right)$	$W = \frac{P_1V_1 - P_2V_2}{n - 1}$
	$S_2 - S_1 = mR\ln\left(\frac{p_1}{p_2}\right) - mC_p \ln\left(\frac{T_1}{T_2}\right)$	$W = \frac{mR(T_1 - T_2)}{n - 1}$
	$\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} = \left[\frac{V_1}{V_2}\right]^{n-1}$	$U_2 - U_1 = mC_v(T_2 - T_1)$ $Q = W + U_2 - U_1$

3. FLOW PROCESS

STEADY FLOW ENERGY EQUATION

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

LAMPIRAN : FORMULA DGP20053 THERMODYNAMICS

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

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

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

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