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 I : 2024 / 2025

DGP20053 : THERMODYNAMICS

TARIKH : 04 DISEMBER 2024
MASA : 2.30 PETANG - 4.30 PETANG (2 JAM)

Kertas ini mengandungi **TUJUH (7)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Buku Jadual Stim dan Formula

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JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

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

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

QUESTION 1
SOALAN 1

CLO1

(a) Thermodynamics system is defined as any space or matter or a group of matter where the energy transfers or energy conversions are studied. It can be classified into three types namely, open system, closed system and isolated system.

Sistem termodinamik ditakrifkan sebagai mana-mana ruang atau jirim atau kumpulan jirim di mana pemindahan tenaga atau penukaran tenaga dikaji. Ia boleh dikelaskan kepada tiga jenis iaitu sistem terbuka, sistem tertutup dan sistem terpencil.

i. Describe closed system.
Terangkan sistem tertutup.

[2 marks]
[*2 markah*]

ii. Give **ONE (1)** example of closed system.
*Berikan **SATU (1)** contoh bagi sistem tertutup.*

[2 marks]
[*2 markah*]

CLO1 (b) 0.04 kg of a certain perfect gas occupies a volume of 0.0072 m^3 at a pressure of 6.76 bar and a temperature of 127°C. When the gas is allowed to expand until the pressure is at 2.12 bar, the final volume is 0.065 m^3. Approximate the:
0.04 kg gas sempurna tertentu menempati isipadu 0.0072 m^3 pada tekanan 6.76 bar dan suhu 127°C. Apabila gas dibiarkan mengembang sehingga tekanan 2.12 bar, isipadu akhir ialah 0.065 m^3. Anggarkan:

i. molecular weight of the gas (*M*).
berat molekul gas (M).

[5 marks]
[*5 markah*]

ii. final temperature.
suhu akhir.

[4 marks]
[*4 markah*]

CLO1 (c) By referring to the steam tables to calculate the specific enthalpy (h), the specific volume (v) and the specific internal energy (u) for the superheated steam at 15 bar and 380°C.
Merujuk jadual stim untuk mengira entalpi tentu (h), isipadu tentu (v) dan tenaga dalaman tentu (u) untuk stim panas lampau pada 15 bar dan 380°C.

[12 marks]
[*12 markah*]

QUESTION 2
SOALAN 2

CLO1 (a) A quantity of gas is compressed isothermally from an initial pressure of 1 bar and an initial volume of 1m^3 through a volume ratio of 8. Approximate:
Kuantiti gas dimampatkan secara isoterma dari tekanan awal 1 bar dan isipadu awal 1m^3 melalui nisbah isipadu 8. Anggarkan:

i. the final pressure.
tekanan akhir.

[3 marks]
[*3 markah*]

ii. the work done.
kerja yang dilakukan.

[3 marks]
[*3 markah*]

CLO1 (b) A mass of gas is heated at a constant pressure of 2.5 bar in a closed system from an initial volume of $0.15m^3$ to a final volume of $0.65m^3$. The initial temperature is 20°C. Calculate:
[Take R = 0.3kJ/kgK and cv = 0.73kJ/kg.]
Jisim gas dipanaskan pada tekanan malar 2.5 bar dalam sistem tertutup dari isipadu awal $0.15m^3$ kepada isipadu akhir $0.65m^3$. Suhu awal ialah 20°C. Kirakan:
[Ambil R = 0.3kJ/kgK and cv = 0.73kJ/kgK.]

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

[12 marks]
[*12 markah*]

ii. the work done and change of internal energy.
kerja yang dilakukan dan perubahan tenaga dalaman.

[7 marks]
[*7 markah*]

QUESTION 3
SOALAN 3

CLO1 (a) Define:
Takrifkan:

i. second law of thermodynamics.
hukum termodinamik kedua.

[3 marks]
[*3 markah*]

ii. heat engine.
enjin haba.

[3 marks]
[*3 markah*]

CLO1 (b) A steam power plant for Rankine cycle operates between a boiler with a pressure of 36 bar and condenser pressure 0.03 bar. If the cycle efficiency is 32.8% while the approximated feed pump and turbine work are 3.597 kJ/kg and 888.1 kJ/kg, respectively, approximate the heat supplied (Q) to the boiler, the work ratio (r_w) and the specific steam consumption (s.s.c.).

Sebuah loji kuasa wap untuk kitar Rankine beroperasi antara tekanan dandang 36 bar dan tekanan pemeluwap 0.03 bar. Jika kecekapan kitaran ialah 32.8% manakala kerja pam suapan dan kerja turbin yang dianggar ialah 3.597 kJ/kg dan 888.1 kJ/kg, anggarkan haba yang dibekalkan (Q) kepada dandang, nisbah kerja (rw) dan penggunaan stim tentu (s.s.c.).

[11 marks]
[*11 markah*]

CLO1 (c) A steady flow of gas enters a condenser at 95°C and 120 m/s and it leaves at 20°C and 10 m/s. The mass flow of the gas through the condenser is 1.8 kg/s. Calculate the heat transfer per second. Take Cp = 1.005 kJ/kgK.
Aliran gas yang mantap memasuki pemeluwap pada 95°C dan 120 m/s dan ia keluar pada 20°C dan 10 m/s. Aliran jisim gas melalui pemeluwap ialah 1.8 kg/s. Kirakan pemindahan haba per saat. Ambil Cp = 1.005 kJ/kgK.

[8 marks]
[*8 markah*]

QUESTION 4

SOALAN 4

CLO1 (a) By reffering to the following reaction at equilibrium:

Dengan merujuk kepada tindak balas berikut pada keseimbangan:

$$CO(g) + 2H_2\,(g) \rightleftharpoons CH_3OH(g)$$

The partial pressures at equilibrium are P_{CO} = 0.5 atm, P_{H2} = 1.50 atm, P_{CH3OH} = 0.3 atm. The temperature at which the reaction occurs is 77°C. Approximate the value of equilibrium constant Kc for the reaction using the relationship between Kp and Kc.

Tekanan separa pada keseimbangan ialah P_{CO} = 0.5 atm, P_{H2} = 1.50 atm, P_{CH3OH} = 0.3 atm. Suhu di mana tindak balas berlaku ialah 77°C. Anggarkan nilai pemalar keseimbangan Kc bagi tindak balas dengan menggunakan hubungan antara Kp dan Kc.

[15 marks]

[*15 markah*]

CLO1 (b)

$$CO\,(g) + O_2\,(g) \leftrightarrows CO_2\,(g)$$

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

Dengan mempertimbangkan tindakbalas 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 298K
CO_2	-394.4
CO	-137.2
O_2	0

i. Write the balanced chemical equation.
Tunjukkan persamaan kimia yang seimbang.

[2 marks]
[*2 markah*]

ii. Calculate ΔG^o for the reaction given.
Kirakan ΔG^o bagi tindakbalas yang diberikan.

[6 marks]
[*6 markah*]

iii. Write whether the reaction is spontaneous or not.
Tuliskan 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 ($V_1 = V$)	$W = 0$ $\quad Q = mC_v(T_2 - T_1)$ $Q = U_2 - U_1$ $S_2 - S_1 = mC_v \ln\left(\frac{T_2}{T_1}\right)$

CONSTANT PRESSURE PROCESS ($P_1 = P_2$)	$W = p(V_2 - V_1)$ $\quad W = mR(T_2 - T_1)$ $Q = mC_p(T_2 - T_1)$ $\quad Q = m(h_2 - h_1)$ $\quad U_2 - U_1 = Q - W$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad S_2 - S_1 = mC_p \ln\left(\frac{T_2}{T_1}\right)$
ADIABATIC (ISENTROPIC)PROCESS	$W = \frac{p_1V_1 - p_2V_2}{\gamma - 1}$ $\quad W = \frac{mR(T_1 - T_2)}{\gamma - 1}$ $W = mC_v(T_1 - T_2)$ $\quad Q = 0$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad S_2 - S_1 = 0$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{\gamma-1}{\gamma}} = \left[\frac{V_1}{V_2}\right]^{\gamma-1}$
POLYTROPIC PROCESS	$S_2 - S_1 = R\ln\left(\frac{v_2}{v_1}\right) - C_v \ln\left(\frac{T_1}{T_2}\right)$ $\quad W = \frac{P_1V_1 - P_2V_2}{n-1}$ $S_2 - S_1 = mR\ln\left(\frac{p_1}{p_2}\right) - mC_p \ln\left(\frac{T_1}{T_2}\right)$ $\quad W = \frac{mR(T_1 - T_2)}{n-1}$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} = \left[\frac{V_1}{V_2}\right]^{n-1}$ $\quad U_2 - U_1 = mC_v(T_2 - T_1)$ $Q = W + U_2 - U_1$

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

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

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

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