Final Examination
2017/2018 Academic Session

May/June 2018

JIK223 – Physical Chemistry I
[Kimia Fizik I]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **NINE** printed pages before you begin the examination.

Answer **FIVE (5)** questions. Answer the questions in English. You may also answer the questions in Bahasa Malaysia, but not a mix of both languages.

All answers must be written in the answer booklet provided.

Each question is worth 20 marks and the mark for each sub question is given at the end of that question.

In the event of any discrepancies in the exam questions, the English version shall be used.

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEMBILAN** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **LIMA (5)** soalan. Jawab soalan-soalan dalam Bahasa Inggeris. Anda juga dibenarkan menjawab soalan dalam Bahasa Malaysia, tetapi campuran antara kedua-dua bahasa ini tidak dibenarkan.*

Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.

Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

…2/-

Answer **FIVE (5)** questions.
*Jawab **LIMA (5)** soalan.*

1. (a). A mixture of 2.50 x 10^{-3} g of O_2, 3.51 x 10^{-3} mol of N_2, and 4.67 x 10^{20} molecules of CO are placed into a vessel of volume 3.50 L at 5.20 ºC.

(i). Calculate the total pressure in the vessel.

(ii). Calculate the mole fractions and partial pressures of each gas.

Suatu campuran 2.50 x 10^{-3} g of O_2, 3.51 x 10^{-3} mol of N_2, dan 4.67 x 10^{20} molekul CO ditempatkan ke dalam suatu bekas berisipadu 3.50 L pada 5.20 ºC.

(i). Kirakan jumlah tekanan di dalam bekas.

(ii). Kirakan pecahan mol dan tekanan separa setiap gas.

[10 marks/*markah*]

(b). An air receiver has a capacity of 0.86 m^3 and contains air at a temperature of 15 ^oC and a pressure of 275 kN m^{-2}. An additional mass of 1.7 kg of air is pumped into the receiver. It is then left until the temperature becomes 15 ^oC once again. Determine;

(i). the new pressure of the air in the receiver,

(ii). the specific enthalpy of the air at 15 ^oC if it is assumed that the specific enthalpy of the air is zero at 0 ^oC.

Take C_p = 1.005 kJ kg^{-1}, C_v = 0.715 kJ kg^{-1} K^{-1}

Suatu penerima udara mempunyai kapasiti 0.86 m^3 dan mengandungi udara pada suhu 15 ^oC dan tekanan 275 kN m^{-2}. Penambahan jisim udara sebanyak 1.7 kg telah dipam ke dalam penerima. Ia kemudiannya dibiarkan sehingga suhu menjadi 15ºC semula. Tentukan;

(i). tekanan udara yang baru dalam penerima,

(ii). entalpi spesifik udara tersebut pada 15 ^oC sekiranya diandaikan bahawa entalpi spesifik udara adalah sifar pada 0 ^oC.

Ambil C_p = 1.005 kJ kg^{-1}, C_v = 0.715 kJ kg^{-1} K^{-1}

[10 marks/*markah*]

…3/-

2. (a). When heat is added to the surroundings, the entropy of the surroundings increases. How does $\Delta S_{surroundings}$ depend on the temperature of the surroundings? Explain.

Apabila haba ditambah kepada persekitaran, entropi persekitaran akan meningkat. Bagaimanakah $\Delta S_{persekitaran}$ bergantung kepada suhu persekitaran? Jelaskan.

[6 marks/*markah*]

(b). Consider the distribution of ideal gas molecules among three bulbs (A, B and C) of equal volume. For each of the following states, determine the number of ways (W) that can be achieved and calculate the entropy:

(i). 2 molecules in bulb A

(ii). 2 molecules randomly distributed among bulbs A, B and C

(iii). 3 molecules in bulb A

(iv). 3 molecules randomly distributed among bulbs A, B and C

(v). 1 mol of molecules in bulb A

(vi). 1 mol of molecules randomly distributed among bulbs A, B and C

(vii). What is ΔS on going from state (v). to (vi).?

Pertimbangkan taburan molekul-molekul gas unggul di antara tiga mentol (A, B dan C) berisipadu sama. Untuk setiap keadaan berikut, tentukan bilangan cara (W) yang boleh dicapai dan kirakan entropi:

(i). 2 molekul dalam mentol A

(ii). 2 molekul ditabur secara rawak antara mentol A, B dan C

(iii). 3 molekul dalam mentol A

(iv). 3 molekul ditabur secara rawak antara mentol A, B dan C

(v). 1 mol molekul dalam mentol A

(vi). 1 mol molekul ditabur secara rawak antara mentol A, B dan C

(vii). Apakah ΔS dari keadaan (v). ke (vi).?

[14 marks/*markah*]

…4/-

3. (a). Calculate the normal boiling point of ethanol (CH_3CH_2OH), given that its enthalpy of vaporisation is 38.6 kJ mol^{-1} and its entropy of vaporisation is 110 J K^{-1} mol^{-1}.

Kirakan takat didih normal etanol (CH_3CH_2OH), diberi entalpi pengewapan ialah 38.6 kJ mol^{-1} dan entropi pengewapannya ialah 110 J K^{-1} mol^{-1}.

[5 marks/*markah*]

(b). At the transition temperature of 95.4 ºC, the enthalpy of transition from rhombic to monoclinic sulfur is 0.38 kJ mol^{-1}.

(i). Calculate the entropy of transition under these conditions.

(ii). At its melting point, 119 ºC, the enthalpy of fusion of monoclinic sulfur is 1.23 kJ mol^{-1}. Calculate the entropy of fusion.

(iii). The values given in parts (i). and (ii). are for 1 mol of sulfur, however, in crystalline and liquid sulfur, the molecule is present as S_8. Convert the values of the enthalpy and entropy of fusion in parts (i). and (ii). to those appropriate for S_8.

Pada suhu peralihan 95.4 ºC, entalpi peralihan daripada sulfur rombik kepada monoklinik ialah 0.38 kJ mol^{-1}.

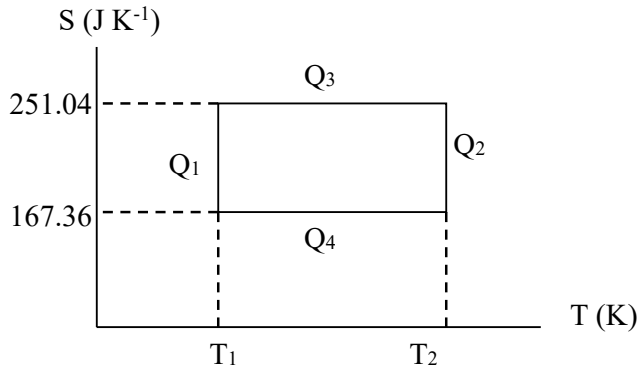
(i). Kirakan entropi peralihan di bawah keadaan ini.

(ii). Pada takat leburnya, iaitu 119 ºC, entalpi pelakuran sulfur monoklinik ialah 1.23 kJ mol^{-1}. Kirakan entropi pelakuran.

(iii). Nilai-nilai yang diberikan dalam bahagian (i). dan (ii). adalah untuk 1 mol sulfur, walaubagaimanapun di dalam sulfur kristal dan cecair, molekulnya hadir sebagai S_8. Tukarkan nilai-nilai entalpi dan entropi pelakuran dalam bahagian (i). dan (ii). kepada nilai S_8 yang sesuai.

[15 marks/*markah*]

4. An ideal heat engine operates through a reversible Carnot cycle between the temperatures T_1= 273 K and T_2 and produces 418.4 J of work per cycle. The changes in entropy associated with this process are shown in the diagram.
Sebuah enjin haba unggul beroperasi melalui kitaran Carnot berbalik di antara suhu T_1 = 273 K dan T_2 dan menghasilkan kerja sebanyak 418.4 J kerja per kitaran. Perubahan dalam entropi yang berkaitan dengan proses ini ditunjukkan dalam gambar rajah di bawah.



(a). Indicate the steps of Carnot cycle in this diagram and the direction along each step.
Tunjukkan langkah-langkah kitaran Carnot dalam gambar rajah ini dan arah bagi setiap langkah.

[5 marks/*markah*]

(b). Calculate Q_1, Q_2, Q_3 and Q_4 for a complete cycle.
Kirakan Q_1, Q_2, Q_3 dan Q_4 untuk kitaran lengkap.

[12 marks/*markah*]

(c). Calculate T_2.
Kirakan T_2.

[3 marks/*markah*]

5. A cell is made from the $Fe^{3+}|$ Fe and the $MnO_4^-|Mn^{2+}$ half cells.
Suatu sel diperbuat daripada setengah sel $Fe^{3+}|$ Fe dan $MnO_4^-|Mn^{2+}$.

(a). Calculate cell potential (E^o_{cell}).
Kirakan keupayaan sel (E^o_{cell}).

[5 marks/*markah*]

(b). Write the overall cell equation.
Tuliskan persamaan keseluruhan sel.

[5 marks/*markah*]

(c). Calculate equilibrium constant (K_{eq}).
Kirakan pemalar keseimbangan tetap (K_{eq}).

[5 marks/*markah*]

(d). Calculate cell potential, E_{cell} when $[Fe^{3+}]$ = 0.10 M, $[MnO_4^-]$ = 0.25 M, $[Mn^{2+}]$ = 1.50 M and the pH is 1.67 at 298 K.
Kirakan keupayaan sel, E_{cell} apabila $[Fe^{3+}]$ = 0.10 M, $[MnO_4^-]$ = 0.25 M, $[Mn^{2+}]$ = 1.50 M dan pH adalah 1.67 pada 298 K.

[5 marks/*markah*]

6. (a). Consider the reaction:

Pertimbangkan tindak balas:

$$Cu^{2+}(aq) + Pb(s) \rightarrow Cu(s) + Pb^{2+}(aq)$$

(i). Draw and label a galvanic cell for this reaction, including the anode, cathode, flow of electrons and direction of flow for the anions and cations.

Lukis dan label sel galvanik untuk tindak balas ini, termasuk anod, katod, aliran elektron dan arah aliran anion dan kation.

(ii). Calculate $E°_{cell}$

Kirakan $E°_{cell}$

(iii). Calculate ΔG°

Kirakan $\Delta G°$

[14 marks/*markah*]

(b). Calculate Δ*G* for the isothermal expansion of 2.50 mol of an ideal gas at 350 K from an initial pressure of 10.50 bar to a final pressure of 0.50 bar.

Kirakan ΔG untuk pengembangan isothermal 2.50 mol gas unggul pada 350 K dari tekanan awal iaitu 10.50 bar kepada tekanan akhir 0.50 bar.

[6 marks/*markah*]

Gas Constant, R in various units

$R = 8.314\ J\ K^{-1}mol^{-1}$

$R = 8.314\ Pa\ m^3\ K^{-1}mol^{-1}$

$R = 8.314 \times 10^{-2}\ L\ bar\ K^{-1}\ mol^{-1}$

Unit of Pressure and Conversion Factors

Unit of Pressure	Symbol	Numerical Value
Pascal	Pa	$1\ N\ m^{-2} = 1\ kg\ m^{-1}s^{-2}$
Atmosphere	atm	1 atm = 101325 Pa
Bar	Bar	1 bar = 105 Pa
Torr or millimeters of Hg	Torr	1 Torr = 101325/760 = 133.32 Pa

$F = 96{,}485\ C\ mol^{-1}$ $C_p = 4.19\ Jg^{-1}K^{-1}$ $K = 1.38 \times 10^{-23}\ J\ K^{-1}$

Types of Work

Types of Work	Variables	Equation for Work	Conventional Units
Volume Expansion	Pressure (P), Volume (V)	$w = -\int P_{external} dV$	$Pam^3 = J$
Stretching	Tension (γ), length (l)	$w = -\int \gamma dl$	$Nm = J$

…9/-

Standard Reduction Potentials at 25°C (298 K) for Many Common Half-Reactions

Half-Reaction	$\mathscr{E}^\circ$ (V)	Half-Reaction	$\mathscr{E}^\circ$ (V)
$F_2 + 2e^- \rightarrow 2F^-$	2.87	$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	0.40
$Ag^{2+} + e^- \rightarrow Ag^+$	1.99	$Cu^{2+} + 2e^- \rightarrow Cu$	0.34
$Co^{3-} + e^- \rightarrow Co^{2-}$	1.82	$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	0.27
$H_2O_2 + 2H^- + 2e^- \rightarrow 2H_2O$	1.78	$AgCl + e^- \rightarrow Ag + Cl^-$	0.22
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	1.70	$SO_4^{2-} + 4H^+ + 2e^- \rightarrow H_2SO_3 + H_2O$	0.20
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	1.69	$Cu^{2+} + e^- \rightarrow Cu^+$	0.16
$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$	1.68	$2H^+ + 2e^- \rightarrow H_2$	0.00
$2e^- + 2H^+ + IO_4^- \rightarrow IO_3^- + H_2O$	1.60	$Fe^{3+} + 3e^- \rightarrow Fe$	−0.036
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	1.51	$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13
$Au^{3+} + 3e^- \rightarrow Au$	1.50	$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14
$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$	1.46	$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23
$Cl_2 + 2e^- \rightarrow 2Cl^-$	1.36	$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.35
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	1.33	$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	1.23	$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	1.21	$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.50
$IO_3^- + 6H^+ + 5e^- \rightarrow \frac{1}{2}I_2 + 3H_2O$	1.20	$Cr^{3+} + 3e^- \rightarrow Cr$	−0.73
$Br_2 + 2e^- \rightarrow 2Br^-$	1.09	$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76
$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	1.00	$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83
$AuCl_4^- + 3e^- \rightarrow Au + 4Cl^-$	0.99	$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18
$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$	0.96	$Al^{3+} + 3e^- \rightarrow Al$	−1.66
$ClO_2 + e^- \rightarrow ClO_2^-$	0.954	$H_2 + 2e^- \rightarrow 2H^-$	−2.23
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	0.91	$Mg^{2+} + 2e^- \rightarrow Mg$	−2.37
$Ag^+ + e^- \rightarrow Ag$	0.80	$La^{3+} + 3e^- \rightarrow La$	−2.37
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	0.80	$Na^+ + e^- \rightarrow Na$	−2.71
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.77	$Ca^{2+} + 2e^- \rightarrow Ca$	−2.76
$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$	0.68	$Ba^{2+} + 2e^- \rightarrow Ba$	−2.90
$MnO_4^- + e^- \rightarrow MnO_4^{2-}$	0.56	$K^+ + e^- \rightarrow K$	−2.92
$I_2 + 2e^- \rightarrow 2I^-$	0.54	$Li^+ + e^- \rightarrow Li$	−3.05
$Cu^+ + e^- \rightarrow Cu$	0.52		

Source : http://pveducation.org/pvcdrom/batteries/standard_potential

- oooOooo -