Final Examination
2018/2019 Academic Session

June 2019

JIK223 – Physical Chemistry I
(Kimia Fizik I)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **TEN (10)** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEPULUH (10)** muka surat yang bercetak sebelum anda memulakan peperiksaan ini].*

Instructions : 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.

*[**Arahan** : 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].*

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

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai].

1. (a). A perfect gas undergoes isothermal compression, which reduces its volume by 2.20 dm^3. The final pressure and volume of the gas are 5.04 bar and 4.65 dm^3 respectively. Calculate the original pressure of the gas in bar and atm unit.

Suatu gas unggul mengalami pemampatan isoterma yang mana mengurangkan isipadunya sebanyak 2.20 dm^3. Tekanan akhir dan isipadu gas masing-masing ialah 5.04 bar dan 4.65 dm^3. Kirakan tekanan asal gas dalam unit bar dan atm.

(8 marks/*markah*)

(b). A gas mixture consists of 320 mg of ethane, 175 mg of argon and 225 mg of neon. The partial pressure of neon at 300 K is 8.87 kPa. Calculate

Satu campuran gas mengandungi 320 mg etana, 175 mg argon dan 225 mg neon. Tekanan separa neon pada 300 K ialah 8.87 kPa. Kirakan

(i). the volume of the mixture.

isipadu campuran tersebut.

(ii). the total pressure of the mixture.

jumlah tekanan campuran tersebut.

(8 marks/*markah*)

(c). Give an example for each of the following situations:

Berikan contoh bagi setiap situasi berikut:

(i). adding heat to a system does not change its temperature.

penambahan haba kepada suatu sistem tidak mengubah suhunya.

(ii). a system’s temperature changes despite no heat being added to it or removed from it.

suhu sistem tersebut berubah walaupun tiada haba ditambahkan kepadanya ataupun disingkirkan daripadanya.

(4 marks/*markah*)

...3/-

2. A cylindrical vessel with rigid adiabatic walls is separated into two sections by a frictionless adiabatic piston. Each section contains 40.0 L of an ideal monatomic gas with $C_{v,m} = \frac{3}{2}R$. Initially, T_i = 298 K and P_i = 1.00 bar in each section. Heat is slowly introduced into the left section using an electrical heater until the piston has moved sufficiently to the right to result in a final pressure P_f = 6.50 bar in the right section. Consider the compression of the gas in the right section to be a reversible process.

Bekas silinder dengan dinding adiabatik tegar telah dibahagikan kepada dua bahagian oleh omboh adiabatik tanpa geseran. Setiap bahagian mengandungi 40.0 L gas monoatomik ideal dengan $C_{v,m} = \frac{3}{2}R$. Pada permulaannya, T_i = 298 K dan P_i = 1.00 bar dalam setiap bahagian. Haba kemudiannya dimasukkan ke bahagian kiri secara perlahan-lahan menggunakan pemanas elektrik sehingga omboh berubah ke sebelah kanan memberikan tekanan akhir P_f = 6.50 bar pada bahagian kanan. Anggapkan pemampatan gas pada bahagian kanan sebagai proses berbalik.

(a). Calculate the work done and the final temperature in the right section of the process.
Kira kerja yang dilakukan dan suhu akhir dalam bahagian kanan dalam proses ini.

(10 marks/*markah*)

(b). Calculate the final temperature in the left section and the amount of heat that flowed into this section.
Kira suhu akhir dalam bahagian kiri dan jumlah haba yang mengalir ke bahagian ini.

(10 marks/*markah*)

3. Initially, the volume and pressure of 0.3 mol of methane gas are 3.90 L and 1 atm respectively. The gas is allowed to expand adiabatically and reversibly to a pressure of 0.1 atm. Assume that the gas behaves ideally and the value of C_p/C_v is 1.31.

Pada awalnya, isipadu dan tekanan bagi 0.3 mol gas metana ialah 3.90 L dan 1 atm masing-masing. Gas itu dibiarkan mengembang secara adiabatik dan berbalik ke tekanan 0.1 atm. Andaikan bahawa gas ini berkelakuan unggul dan nilai C_p/C_v ialah 1.31.

(a). What are the initial and final temperature of the gas?
Apakah suhu awal dan akhir gas tersebut?

(5 marks/*markah*)

(b). Calculate q,w, ΔU and ΔH in joule.
Hitung q,w, ΔU dan ΔH dalam unit joule.

(8 marks/*markah*)

(c). Could a process be carried out isothermally? Give your reason.
Bolehkah proses ini dijalankan secara isoterma? Berikan alasan anda.

(3 marks/*markah*)

(d). Suggest an alternative path to attain the same final state. Sketch both paths in *P-V* diagram.
Cadangkan suatu laluan alternatif untuk mencapai keadaan akhir yang sama. Lakarkan kedua-dua laluan tersebut dalam gambar rajah P-V.

(4 marks/*markah*)

4. (a). One mole of an ideal gas with $C_{V,m} = \frac{3}{2}R$ is transformed from an initial state T = 800 K and P = 2.00 bar to a final state T = 450 K and P = 6.50 bar. Calculate ΔU, ΔH, and ΔS for this process.

Satu mol gas unggul dengan $C_{V,m} = \frac{3}{2}R$ telah mengalami tranformasi dari keadaan awal T = 800 K dan P = 2.00 bar kepada keadaan akhir T = 450 K dan P = 6.50 bar. Kirakan ΔU, ΔH, and ΔS untuk proses ini.

(15 marks/*markah*)

(b). Calculate the Gibbs free energy difference (*ΔG)* for the isothermal expansion of 4.50 mol of an ideal gas at 300 K from an initial pressure of 8.50 bar to a final pressure of 1.50 bar.

Kirakan perubahan tenaga bebas Gibbs (ΔG) untuk pengembangan isoterma 4.50 mol gas unggul pada 300 K dari tekanan awal iaitu 8.5 bar kepada tekanan akhir 1.50 bar.

(5 marks/*markah*)

5. (a). An alkaline battery consists of a powdered Zn/gel anode and a C/MnO_2 cathode. At the anode, Zn is oxidised to Zn^{2+} which reacts with the OH^- ion present in the paste to form $Zn(OH)_2$(s). Suppose that an alkaline battery was manufactured using Fe metal instead of Zn metal, and that the Fe was oxidised to Fe^{2+} at the anode. What effect would this have on the cell potential or emf of the battery? Explain your answer briefly.

Suatu bateri alkali mengandungi suatu anod Zn/gel serbuk dan suatu katod C/MnO_2. Di anod, Zn telah dioksidakan kepada Zn^{2+} yang mana bertindak balas dengan ion OH^- yang hadir dalam pes untuk membentuk $Zn(OH)_2$(p). Sepatutnya bateri alkali tersebut dibuat menggunakan logam Fe berbanding logam Zn, dan Fe tersebut akan dioksidakan kepada Fe^{2+} pada anod. Apakah kesannya ke atas keupayaan sel dan emf bateri tersebut? Terangkan jawapan anda secara ringkas.

(5 marks/*markah*)

(b). The redox reaction that occurs in a voltaic cell at 25 °C is

Tindak balas redoks yang berlaku dalam suatu sel voltan pada 25 °C ialah

$$2Au^{3+}(aq) + 3Ni(s) \rightarrow 3Ni^{2+}(aq) + 2Au(s)$$

(i). Calculate the standard cell potential, E°_{cell}, for the cell.

Kirakan keupayaan sel piawai, E°_{sel} sel tersebut.

(ii). Calculate the cell potential, E_{cell}, for the cell when $[Au^{3+}] = 1.2 \times 10^{-6}$ M and $[Ni^{2+}] = 1.10$ M.

Kirakan keupayaan sel, E_{sel} untuk sel tersebut apabila $[Au^{3+}] = 1.2 \times 10^{-6}$ M dan $[Ni^{2+}] = 1.10$ M.

(10 marks/*markah*)

(c). Distinguish between an electrolytic cell and a voltaic cell.

Bezakan di antara sel elektrolisis dan sel voltan.

(5 marks/*markah*)

6. (a). Rechargeable nickel-cadmium or "ni-cad" batteries are used in calculators and portable power tools. The half-reactions that occur in a ni-cad battery are:
Bateri nikel-kadmium yang boleh dicas semula ataupun bateri "ni-cad" digunakan dalam kalkulator dan alat kuasa mudah alih. Tindakbalas setengah yang berlaku dalam bateri ni-cad ialah:

Anode: $Cd(s) + 2OH^{-}(aq) \rightarrow Cd(OH)_2(s) + 2e^{-}$
Cathode: $NiO(OH)(s) + H_2O(l) + e^{-} \rightarrow Ni(OH)_2(s) + OH^{-}(aq)$

Explain in specific chemical terms what it means by rechanging the battery.
Jelaskan dalam terma kimia spesifik apakah yang dimaksudkan untuk pengecasan semula bateri.

(4 marks/*markah*)

(b). A voltaic cell utilizes the following redox reaction:
Suatu sel voltan menggunakan tindak balas redoks berikut:

$$Bi(s) + 3Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq) + Bi^{3+}(aq)$$

(i). Identify the oxidizing agent in the reaction.
Kenalpasti agen pengoksidaan dalam tindak balas.

(ii). How many electrons are transferred in the redox reaction
Berapa banyak elektron yang dipindahkan dalam tindak balas redoks?

(iii). Calculate the standard cell potential, E°_{cell}, for this electrochemical cell.
Kirakan keupayaan sel piawai E^{o}_{sel}, untuk sel elektrokimia ini.

(iv). Calculate the equilibrium constant for the redox reaction.
Kirakan pemalar keseimbangan untuk tindak balas redoks.

(16 marks/*markah*)

...8/-

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 x 10^{-2} L bar K^{-1} mol^{-1}

R = 0.0821 atm L K^{-1} mol^{-1}

R = 62.36 L Torr K^{-1} mol^{-1}

Unit of Pressure and Conversion Factors

Unit of Pressure	Symbol	Numerical Value
Pascal	Pa	1 Nm^{-2} = 1 $kgm^{-1}s^{-2}$
Atmosphere	atm	1 atm = 101325 Pa
Bar	Bar	1 bar = 10^5 Pa
Torr or millimeters of Hg	Torr	1 Torr = 101325/760 = 133.32 Pa

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

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

Standard Potentials at 25°C

Half Reaction	Potential
$F_2 + 2e^- \rightarrow 2F^-$	+2.87 V
$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$	+2.07 V
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.05 V
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	+1.69 V
$Au^+ + e^- \rightarrow Au$	+1.69 V
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$	+1.67 V
$2\ HClO + 2H^+ + 2e^- \rightarrow Cl_2 + 2H_2O$	+1.63 V
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	+1.61 V
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	+1.51 V
$Au^{3+} + 3e^- \rightarrow Au$	+1.40 V
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36 V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	+1.33 V
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23 V
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+1.21 V
$Pt^{2+} + 2e^- \rightarrow Pt$	+1.20 V
$Br_2 + 2e^- \rightarrow 2Br^-$	+1.09 V
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	+0.92 V
$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$	+0.89 V
$Ag^+ + e^- \rightarrow Ag$	+0.80 V
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	+0.79 V
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77 V
$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$	+0.60 V
$I_2 + 2e^- \rightarrow 2I^-$	+0.54 V
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	+0.40 V
$Cu^{2+} + 2e^- \rightarrow Cu$	+0.34 V
$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	+0.27 V
$AgCl + e^- \rightarrow Ag + Cl^-$	+0.22 V
$NO_3^- + H_2O + 2e^- \rightarrow NO_2^- + 2OH^-$	+0.01 V
$2H^+ + 2e^- \rightarrow H_2$	**0.000 V**
$Bi^{3+} + 3e^- \rightleftharpoons Bi(s)$	+0.308 V

Half Reaction	Potential
$2H^+ + 2e^- \rightarrow H_2$	**0.000 V**
$Fe^{3+} + 3e^- \rightarrow Fe$	−0.04 V
$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13 V
$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14 V
$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23 V
$V^{3+} + e^- \rightarrow V^{2+}$	−0.26 V
$Co^{2+} + 2e^- \rightarrow Co$	−0.28 V
$In^{3+} + 3e^- \rightarrow In$	−0.34 V
$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.36 V
$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40 V
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.41 V
$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44 V
$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76 V
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83 V
$Cr^{2+} + 2e^- \rightarrow Cr$	−0.91 V
$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18 V
$V^{2+} + 2e^- \rightarrow V$	−1.19 V
$ZnS + 2e^- \rightarrow Zn + S^{2-}$	−1.44 V
$Al^{3+} + 3e^- \rightarrow Al$	−1.66 V
$Mg^{2+} + 2e^- \rightarrow Mg$	−2.36 V
$Na^+ + e^- \rightarrow Na$	−2.71 V
$K^+ + e^- \rightarrow K$	−2.92 V
$Li^+ + e^- \rightarrow Li$	−3.05 V

Note: all ions are aqueous (aq), many neutral species are solids (s), although some are liquids (l), gases (g), and even aqueous (aq). Use other sources for details on state. They were purposely left off here to save space and keep a cleaner looking table.

...10/-

IUPAC Periodic Table of the Elements

Key:

atomic number
Symbol
name
standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen [1.007, 1.009]																	2 **He** helium 4.003
3 **Li** lithium [6.938, 6.997]	4 **Be** beryllium 9.012											5 **B** boron [10.80, 10.83]	6 **C** carbon [12.00, 12.02]	7 **N** nitrogen [14.00, 14.01]	8 **O** oxygen [15.99, 16.00]	9 **F** fluorine 19.00	10 **Ne** neon 20.18
11 **Na** sodium 22.99	12 **Mg** magnesium [24.30, 24.31]											13 **Al** aluminium 26.98	14 **Si** silicon [28.08, 28.09]	15 **P** phosphorus 30.97	16 **S** sulfur [32.05, 32.08]	17 **Cl** chlorine [35.44, 35.46]	18 **Ar** argon 39.95
19 **K** potassium 39.10	20 **Ca** calcium 40.08	21 **Sc** scandium 44.96	22 **Ti** titanium 47.87	23 **V** vanadium 50.94	24 **Cr** chromium 52.00	25 **Mn** manganese 54.94	26 **Fe** iron 55.85	27 **Co** cobalt 58.93	28 **Ni** nickel 58.69	29 **Cu** copper 63.55	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.72	32 **Ge** germanium 72.63	33 **As** arsenic 74.92	34 **Se** selenium 78.97	35 **Br** bromine [79.90, 79.91]	36 **Kr** krypton 83.80
37 **Rb** rubidium 85.47	38 **Sr** strontium 87.62	39 **Y** yttrium 88.91	40 **Zr** zirconium 91.22	41 **Nb** niobium 92.91	42 **Mo** molybdenum 95.95	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57-71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium [204.3, 204.4]	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium	113 **Uut** ununtrium	114 **Fl** flerovium	115 **Uup** ununpentium	116 **Lv** livermorium	117 **Uus** ununseptium	118 **Uuo** ununoctium

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.3	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium 231.0	92 **U** uranium 238.0	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 8 January 2016.

- oooOooo -