一、單選題（每題2.5分，答錯不倒扣）

元素原子量：H=1, D=2, C=12, N=14, O=16, F=19, Na=23, S=32, Cl=35.5, P=31, K=39, Ca=40, Mn=55, Fe=55.85, Br=80, Rb=85.5, I=127 ; Faraday constant=96500 $Cmol^{-1}$, Gas constant R=8.314 J K^{-1} mol^{-1}; 5.189×10^{19} eV K^{-1} mol^{-1} or 0.082 L atm K^{-1} mol^{-1}, Plank Constant h=6.626×10^{-34} J • s

[1]. For the reaction of sodium bromide with chlorine gas to form sodium chloride and bromine, the appropriate half-reactions are (ox = oxidation and re = reduction):

A) ox: $Cl_2 + 2e^- \rightarrow 2Cl^-$; re: $2Br^- \rightarrow Br_2 + 2e^-$

B) ox: $2Br^- \rightarrow Br_2 + 2e^-$; re: $Cl_2 + 2e^- \rightarrow 2Cl^-$

C) ox: $Cl + e^- \rightarrow Cl^-$; re: $Br \rightarrow Br^- + e^-$

D) ox: $Br + 2e^- \rightarrow Br^{2-}$; re: $2Cl^- \rightarrow Cl_2 + 2e^-$

E) ox: $2Na^+ + 2e^- \rightarrow 2Na$; re: $2Cl^- \rightarrow Cl_2 + 2e^-$

[2]. The following reactions:

$Pb^{2+} + 2I^- \rightarrow PbI_2$

$2Ce^{4+} + 2I^- \rightarrow I_2 + 2Ce^{3+}$

$HOAc + NH_3 \rightarrow NH_4^+ + OAc^-$

are examples of

A) acid-base reactions.

B) unbalanced reactions.

C) precipitation, acid-base, and redox reactions, respectively.

D) redox, acid-base, and precipitation reactions, respectively.

E) precipitation, redox, and acid-base reactions, respectively.

[3]. What volume of 18.0 M sulfuric acid must be used to prepare 15.5 L of 0.195 M H_2SO_4?

A) 168 mL

B) 0.336 L

C) 92.3 mL

D) 226 mL

E) none of these

[4]. Air has an average molar mass of 29.0 g/mol. The density of air at 1.00 atm and 30°C is

A) 29.0 g/L

B) 40.0 g/mL

C) 1.17 g/L

D) 1.29 g/L

E) 12 g/L

注意:背面有試題

[5]. Consider the following gas samples:

Sample A	Sample B
$S_2(g)$	$O_2(g)$
$n = 1$ mol	$n = 2$ mol
$T = 800$ K	$T = 400$ K
$P = 0.20$ atm	$P = 0.40$ atm

Which one of the following statements is *false*?

A) The volume of sample A is twice the volume of sample B.

B) The average kinetic energy of the molecules in sample A is twice the average kinetic energy of the molecules in sample B.

C) The fraction of molecules in sample A having a kinetic energy greater than some high fixed value is larger than the fraction of molecules in sample B having kinetic energies greater than that same high fixed value.

D) The mean square velocity of molecules in sample A is twice as large as the mean square velocity of molecules in sample B.

E) Assuming identical intermolecular forces in the two samples, sample A should be more nearly ideal than sample B.

[6]. Consider the following ground state electron configuration: $1s^2 2s^2 2p^4$. Which of the ions has this ground state electron configuration?

A) F^{-1}

B) N^{+1}

C) C^{-2}

D) O^{-2}

[7]. Which ionization process requires the most energy?

A) $Al(g) \rightarrow Al^{+}(g) + e^{-}$

B) $Al^{+}(g) \rightarrow Al^{2+}(g) + e^{-}$

C) $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^{-}$

D) $Al^{3+}(g) \rightarrow Al^{4+}(g) + e^{-}$

[8]. Which type of spherical packing has the most **unused** space?

A) body-centered cubic

B) cubic closest-packed

C) cubic closest-packed and hexagonal closest-packed

D) simple cubic

[9]. What is the edge length of a face-centered cubic unit cell made up of atoms having a radius of 200 pm?

A) 71 pm

B) 566 pm

C) 20 pm

D) 110 pm

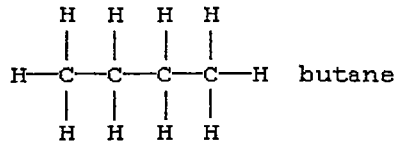
注意:背面有試題

[10]. KBr crystallizes in a cubic unit cell with Br^- ions on each corner and each face. How many K^+ ions and Br^- ions are in each unit cell of KBr?

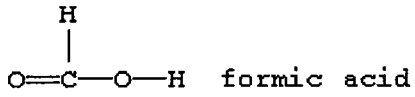
A) 1 K^+ ion and 1 Br^- ion
B) 2 K^+ ions and 2 Br^- ions
C) 4 K^+ ions and 4 Br^- ions
D) 8 K^+ ions and 8 Br^- ions

[11]. Which should be **least** soluble in water?

A)



B)



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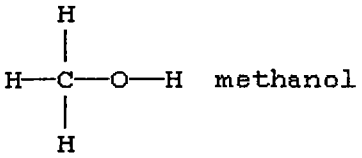
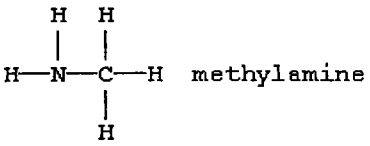


D)



[12]. A solution is prepared by dissolving 17.75 g sulfuric acid, H_2SO_4, in enough water to make 100.0 mL of solution. If the density of the solution is 1.1094 g/mL, what is the molality?

A) 0.1775 *m* H_2SO_4
B) 0.1810 *m* H_2SO_4
C) 1.810 *m* H_2SO_4
D) 1.940 *m* H_2SO_4

[13]. In general, as the temperature increases, the solubility of gases in water _____ and the solubility of most solids in water _____.

A) decreases, decreases
B) decreases, increases
C) increases, decreases
D) increases, increases

注意:背面有試題

[14]. A solution is prepared by dissolving 20.0 g of sucrose, $C_{12}H_{22}O_{11}$, in 250. g of water at 25°C. What is the vapor pressure of the solution if the vapor pressure of water at 25°C is 23.76 mm Hg?

A) 0.198 mm Hg
B) 20.5 mm Hg
C) 23.7 mm Hg
D) 24.0 mm Hg

[15]. Assuming that sea water is a 3.5 wt % solution of NaCl in water, calculate its osmotic pressure at 20°C. The density of a 3.5% NaCl solution at 20°C is 1.023 g/mL.

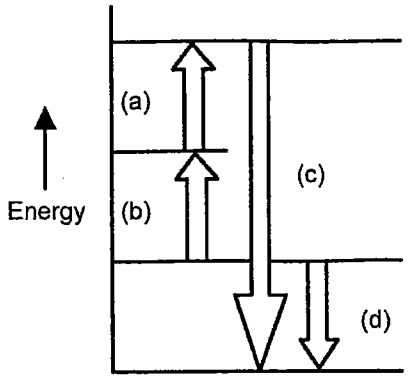
A) 1.0 atm
B) 15 atm
C) 29 atm
D) 100 atm

[16]. A solution of a nonelectrolyte solution contains 30.0 g of solute dissolved in 250.0g of water. The freezing point of the water is observed to be -2.50°C. The K_f for water is 1.86 °C/m and normal freezing point of water is 0.00°C. What is the molar mass of the substance?

A) 335 g/mol
B) 89.5 g/mol
C) 895 g/mol
D) 33.5 g/mol

[17]-[18]. Arrows in the energy diagram below represent enthalpy changes occurring in the exothermic formation of a solution:

ΔH_{soln} = enthalpy of solution
$\Delta H_{solute\text{-}solute}$ = enthalpy change involving solute-solute interactions
$\Delta H_{solute\text{-}solvent}$ = enthalpy change involving solute-solvent interactions
$\Delta H_{solvent\text{-}solvent}$ = enthalpy change involving solvent-solvent interactions



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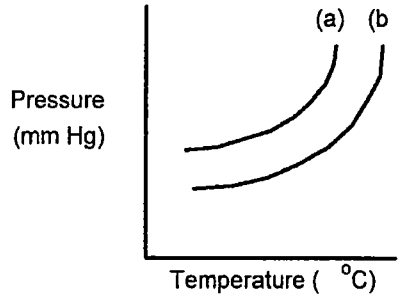
[17]. Which arrow represents ΔH_{soln}?

A) arrow (a)
B) arrow (b)
C) arrow (c)
D) arrow (d)

[18]. Which arrow represents $\Delta H_{solute\text{-}solvent}$?

A) arrow (a)
B) arrow (b)
C) arrow (c)
D) arrow (d)

[19]. The following diagram shows a close-up view of the vapor pressure curves for a pure solvent and a solution containing a nonvolatile solute dissolved in this solvent.



Which curve is the solvent and what happens to the vapor pressure when the solute is dissolved in the solvent?

A) Curve (a) is the solvent and the vapor pressure decreases.
B) Curve (a) is the solvent and the vapor pressure increases.
C) Curve (b) is the solvent and the vapor pressure decreases.
D) Curve (b) is the solvent and the vapor pressure increases.

[20]. What is the mole fraction of oxygen in a gas mixture that is 27% oxygen and 73% nitrogen by volume?

A) 0.24
B) 0.27
C) 0.32
D) 0.37

[21]. A concentration-time study of the gas phase reaction $2\ A_3 \rightarrow 3\ A_2$ produced the data in the table below.

Time (s)	$[A_3]$ (M)	$[A_2]$ (M)
0	4.00×10^{-4}	0
10	2.00×10^{-4}	3.00×10^{-4}
20	1.00×10^{-4}	4.50×10^{-4}
30	5.00×10^{-5}	?

What is the concentration of A_2 after 30 seconds?

A) 5.00×10^{-4} M
B) 5.25×10^{-4} M
C) 5.50×10^{-4} M
D) 6.00×10^{-4} M

[22]. The following set of data was obtained by the method of initial rates for the reaction:

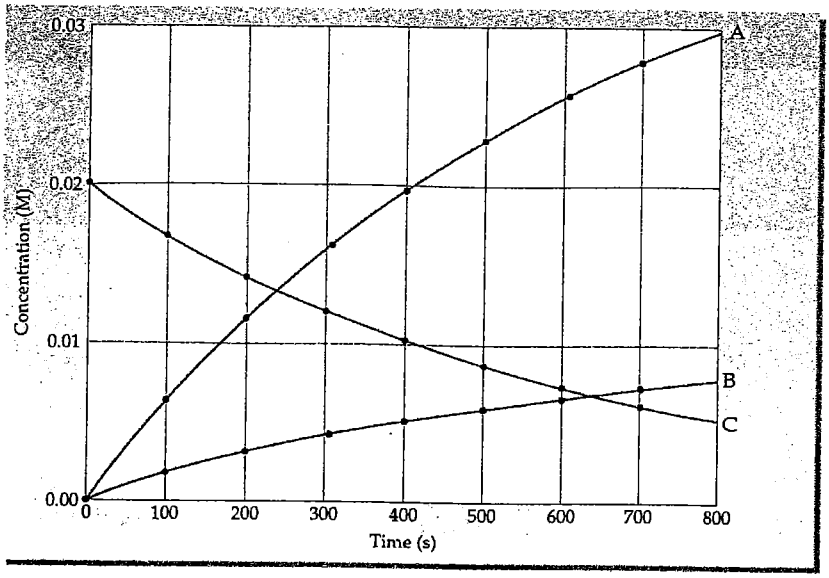
$$BrO_3^-(aq) + 5\ Br^-(aq) + 6\ H^+(aq) \rightarrow 3\ Br_2(aq) + 3\ H_2O(l).$$

Calculate the initial rate when BrO_3^- is 0.30 M, Br^- is 0.050 M, and H^+ is 0.15 M.

Expt	$[BrO_3^-]$ (M)	$[Br^-]$ (M)	$[H^+]$ (M)	Rate (M/s)
1	0.10	0.10	0.10	8.0×10^{-4}
2	0.20	0.10	0.10	1.6×10^{-3}
3	0.20	0.15	0.10	2.4×10^{-3}
4	0.10	0.10	0.25	5.0×10^{-3}

A) 6.1×10^{-5} M/s
B) 2.7×10^{-3} M/s
C) 5.3×10^{-2} M/s
D) 8.4×10^{-2} M/s

[23]. Shown is a concentration versus time plot for a reaction involving gases A, B, and C.



Which equation best represents the reaction?

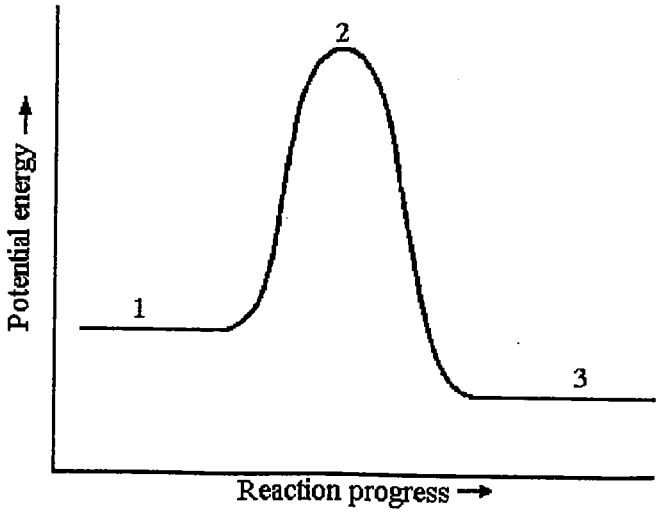
A) $4A(g) \rightarrow B(g) + 2C(g)$

B) $4A(g) + B(g) \rightarrow 2C(g)$

C) $2C(g) \rightarrow 4A(g) + B(g)$

D) $2C(g) + B(g) \rightarrow 4A(g)$

[24]. Consider a reaction that occurs by the following one-step mechanism: $A_2 + B_2 \rightarrow 2\ AB$
The potential energy profile for this reaction is shown below.



What is the species present at reaction stage 1?

A) an intermediate

B) a product

C) a reactant

D) a transition state

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[25]. The following set of data was obtained by the method of initial rates for the reaction:

$$2\ HgCl_2(aq) + C_2O_4^{2-}(aq) \rightarrow 2\ Cl^-(aq) + 2\ CO_2(g) + Hg_2Cl_2(s)$$

What is the rate law for the reaction?

$[HgCl_2]$ (M)	$[C_2O_4^{2-}]$ (M)	Rate (M/s)
0.10	0.10	1.3×10^{-7}
0.10	0.20	5.2×10^{-7}
0.20	0.20	1.0×10^{-6}

A) Rate = $k[HgCl_2][C_2O_4^{2-}]^{-2}$
B) Rate = $k[HgCl_2][C_2O_4^{2-}]^{-1}$
C) Rate = $k[HgCl_2]^2[C_2O_4^{2-}]$
D) Rate = $k[HgCl_2][C_2O_4^{2-}]^2$

[26]. For a particular first-order reaction, it takes 48 minutes for the concentration of the reactant to decrease to 25% of its initial value. What is the value for rate constant (in s^{-1}) for the reaction?

A) $1.0 \times 10^{-4}\ s^{-1}$
B) $4.8 \times 10^{-4}\ s^{-1}$
C) $6.0 \times 10^{-3}\ s^{-1}$
D) $2.9 \times 10^{-2}\ s^{-1}$

[27]. The reaction: $2\ HI \rightarrow H_2 + I_2$, is second order and the rate constant at 800 K is $9.70 \times 10^{-2}\ M^{-1}\ s^{-1}$. How long will it take for 8.00×10^{-2} mol/L of HI to decrease to one-fourth of its initial concentration?

A) 0.619 s
B) 124 s
C) 387 s
D) 429 s

[28]. What are the coefficients in front of $NO_3^-(aq)$ and Cu(s) when the following redox equation is balanced in an acidic solution:

_____ $NO_3^-(aq)$ + _____ $Cu(s) \rightarrow$ _____ $NO(g)$ + _____ $Cu^{2+}(aq)$?

A) 2, 3
B) 2, 6
C) 3, 4
D) 3, 6

注意:背面有試題

[29]. Determine the number of water molecules necessary to balance the following chemical equation.

$$Cr_2O_7^{2-}(aq) + Cl^-(aq) + H^+(aq) \rightarrow Cr^{3+}(aq) + Cl_2(g) + \_\_\_\_\_ H_2O(l)$$

A) 3
B) 5
C) 7
D) 14

[30]. The iron content of foods can be determined by dissolving them in acid (forming Fe^{3+}), reducing the iron(III) to iron(II), and titrating with cerium(IV):

$$Fe^{2+}(aq) + Ce^{4+}(aq) \rightarrow Fe^{3+}(aq) + Ce^{3+}(aq).$$

Identify the two half-reactions in the above reaction.

A) oxidation half-reaction $Fe^{2+}(aq) + e^- \rightarrow Fe^{3+}(aq)$ reduction half-reaction $Ce^{4+}(aq) \rightarrow Ce^{3+}(aq) + e^-$
B) oxidation half-reaction $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$ reduction half-reaction $Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$
C) oxidation half-reaction $Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$ reduction half-reaction $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$
D) oxidation half-reaction $Ce^{4+}(aq) \rightarrow Ce^{3+}(aq) + e^-$ reduction half-reaction $Fe^{2+}(aq) + e^- \rightarrow Fe^{3+}(aq)$

[31]. For the hypothetical reaction $A + 2\,B^{x+} \rightarrow A^{y+} + 2\,B^{3+}$, $E° = 1.50$ V, and $\Delta G° = -305$ kJ. For this reaction, if the value of x is 4, then the value of y = _____.

A) 1
B) 2
C) 3
D) 4

[32]. Given:
$Ag^+(aq) + e^- \rightarrow Ag(s)$ $E° = +0.799$ V
$AgI(s) + e^- \rightarrow Ag(s) + I^-(aq)$ $E° = -0.152$ V
$Ni^{2+}(aq) + 2\,e^- \rightarrow Ni(s)$ $E° = -0.267$ V

Which of the following reactions should be spontaneous under standard conditions?

I. $2\,AgI(s) + Ni(s) \rightarrow 2\,Ag(s) + 2\,I^-(aq) + Ni^{2+}(aq)$
II. $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$

A) I and II are both nonspontaneous.
B) I is nonspontaneous and II is spontaneous.
C) I is spontaneous and II is nonspontaneous.
D) I and II are both spontaneous.

注意:背面有試題

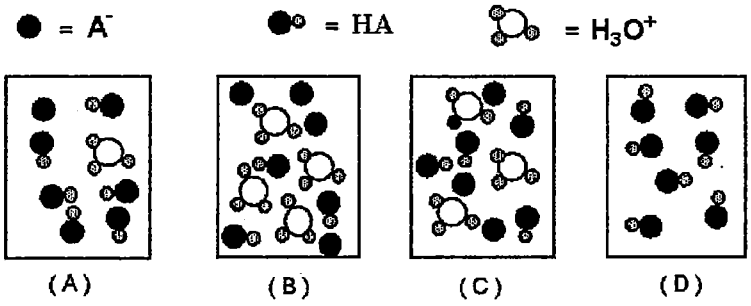
[33]. At a certain temperature, K_C equals 1.4×10^2 for the reaction:

$$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g).$$

If a 2.50-L flask contains 0.400 mol of CO_2 and 0.100 mol of O_2 at equilibrium, how many moles of CO are also present in the flask?

A) 0.422 mol
B) 0.169 mol
C) 0.107 mol
D) 0.0114 mol

[34]. The following pictures represent aqueous solutions of binary acids of the type HA where the water molecules have been omitted for clarity.



Determine the strongest acid of the set.

A) A
B) B
C) C
D) D

[35]. What is the second stepwise equilibrium constant expression for phosphoric acid H_3PO_4?

A) $K_{a2} = ([H_3O^+][H_2PO_4^-])/([H_3PO_4])$
B) $K_{a2} = ([H_3O^+]2[HPO_4^{2-}])/([H_3PO_4])$
C) $K_{a2} = ([H_3O^+]3[PO_4^{3-}])/([H_3PO_4])$
D) $K_{a2} = ([H_3O^+][HPO_4^{2-}])/([H_2PO_4^-])$

[36]. Sodium reacts violently with water according to the equation:

$$2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$$

The resulting solution has a higher temperature than the water prior to the addition of sodium. What are the signs of $\Delta H°$ and $\Delta S°$ for this reaction?

A) $\Delta H°$ is negative and $\Delta S°$ is negative.
B) $\Delta H°$ is negative and $\Delta S°$ is positive.
C) $\Delta H°$ is positive and $\Delta S°$ is negative.
D) $\Delta H°$ is positive and $\Delta S°$ is positive.

注意:背面有試題

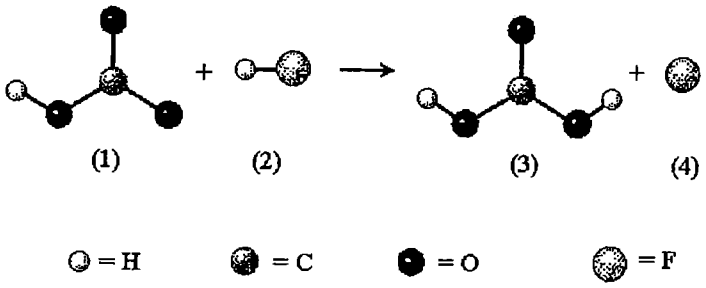
[37]. For the process

$$CaCO_3(\text{calcite}) \rightarrow CaCO_3(\text{aragonite})\ \Delta H° = -0.21\ \text{kJ},\ \Delta S° = -4.2\ \text{J/K}$$

Assuming that the surroundings can be considered a large heat reservoir at 25°C, calculate ΔS_{surr} and ΔS_{total} for the process at 25°C and 1 atm pressure. Is the process spontaneous at 25°C and 1 atm pressure?

A) $\Delta S_{surr} = 4.2$ J/K, $\Delta_{total} = 0$, not spontaneous
B) $\Delta S_{surr} = 0.7$ J/K, $\Delta S_{total} = -3.5$ J/K, not spontaneous
C) $\Delta S_{surr} = -0.7$ J/K, $\Delta S_{total} = -4.9$ J/K, spontaneous
D) $\Delta S_{surr} = -0.7$ J/K, $\Delta S_{total} = -4.9$ J/K, not spontaneous

[38]. In the following reaction the unshaded spheres represent H atoms.



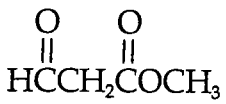
Identify the BrØnsted-Lowry acid/base conjugate pairs.

A) (1)/(2) and (3)/(4)
B) (1)/(3) and (2)/(4)
C) (1)/(4) and (2)/(3)
D) none of the above.

[39]. An experiment with ^{55}Co takes 47.5 hours. At the end of the experiment, 1.90 ng of ^{55}Co remains. If the half life is 18.0 hours, how many ng of ^{55}Co were originally present?

A) 2.47 ng
B) 3.05 ng
C) 3.28 ng
D) 11.8 ng

[40]. The functional groups in the molecule below are



A) alkane, aldehyde, and ester.
B) alkane, aldehyde, ketone, and ether.
C) alkane, carboxylic acid, and ester.
D) alkane, ketone, and ester.