

說明：答案一律寫在試卷上；請依序作答，並標明題號。

選擇題：(單選；1-30 每題 2 分，不倒扣，共 60 分；31-40 每題 4 分，共 40 分，答錯倒扣 2 分)

- Which is **not** the correct chemical formula for the compound named  
(A). sodium sulfate  $\text{Na}_2\text{SO}_4$  (B). potassium chloride  $\text{KCl}$  (C). ammonium sulfide  $(\text{NH}_4)_2\text{S}$   
(D). barium nitrate  $\text{Ba}(\text{NO}_3)_2$  (E). calcium oxide  $\text{Ca}_2\text{O}$
- Choose the compound with the most ionic bond.  
(A).  $\text{LiCl}$  (B).  $\text{KF}$  (C).  $\text{NaCl}$  (D).  $\text{LiF}$  (E).  $\text{KCl}$
- The mass percent of iron in an iron oxide is 77.7%. Find the empirical formula. (MW: Fe:55.8; O:16)  
(A).  $\text{Fe}_3\text{O}_2$  (B).  $\text{Fe}_3\text{O}_4$  (C).  $\text{Fe}_2\text{O}_3$  (D).  $\text{FeO}$  (E).  $\text{Fe}_4\text{O}_3$
- Boron naturally occurs in two isotopic forms. The more common isotope is  $^{11}\text{B}$  (atomic mass 11.01 amu), which is 80.00% abundant. The average atomic mass of boron is 10.81. What is the mass of the other isotope?  
(A). 10.01 amu. (B). 10.21 amu (C). 10.41 amu (D). 10.61 amu. (E). 10.81 amu.
- If all of the chloride in a 5.000-g sample of an unknown metal chloride is precipitated as  $\text{AgCl}$  with 70.90 mL of 0.2010 M  $\text{AgNO}_3$ , what is the percentage of chloride in the sample? (MW: Cl:35.45)  
(A). 5.05% (B). 10.10% (C). 15.55% (D). 20.22% (E). 25.55 %
- A solution contains the ions  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ , and  $\text{Ni}^{2+}$ . Dilute solutions of  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ , and  $\text{Na}_2\text{S}$  are available to separate the positive ions from each other. In order to effect separation, the solutions should be added in which order?  
(A).  $\text{Na}_2\text{SO}_4$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$  (B).  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$  (C).  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$   
(D).  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$ ,  $\text{Na}_2\text{SO}_4$  (E).  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$ .
- An aqueous solution of silver nitrate is added to an aqueous solution of potassium chromate and this reaction produces a solid. What is the formula for the solid?  
(A).  $\text{AgK}$  (B).  $\text{AgCrO}_4$  (C).  $\text{KNO}_3$  (D).  $\text{K}_2\text{NO}_3$  (E).  $\text{Ag}_2\text{CrO}_4$
- The diffusion rate of  $\text{N}_2$  gas is 1.73 times as great as a noble gas (both gases are at the same temperature). What is the noble gas? (MW:  $\text{N}_2$ : 28, He: 4, Ne: 20.2, Ar: 40, Kr: 83.8, Xe: 131.3)  
(A). He (B). Ne (C). Ar (D). Kr (E). Xe
- The volume of a balloon is 1.20 liters at  $24.0^\circ\text{C}$ . The balloon is heated to  $48.0^\circ\text{C}$ . Calculate the new volume of the balloon. (absolute temperature,  $\text{K} = 273 + ^\circ\text{C}$ )  
(A). 1.3 L (B). 1.7 L (C). 2.1 L (D). 2.4 L (E). 2.5L
- To increase the value of  $K$  for the following exothermic reaction:  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g})$   
(A). decrease the total pressure (B). increase the total pressure (C). decrease the temperature  
(D). increase the temperature (E). increase the total volume
- According to the Bronsted-Lowry definition, an acid is  
(A). a substance that increases the hydroxide concentration ion concentration in a solution.  
(B). a substance that increases the hydrogen ion concentration ion concentration in a solution.  
(C). a substance that can accept a proton from another species in a solution.  
(D). a substance that can donate a proton to another species.  
(E). an electron pair acceptor.
- The acids  $\text{HC}_2\text{H}_3\text{O}_2$  and  $\text{HF}$  are both weak, but  $\text{HF}$  is a stronger acid than  $\text{HC}_2\text{H}_3\text{O}_2$ .  $\text{HCl}$  is a strong acid. Order the following according to base strength.  
(A).  $\text{C}_2\text{H}_3\text{O}_2^- > \text{F}^- > \text{Cl}^- > \text{H}_2\text{O}$  (B).  $\text{C}_2\text{H}_3\text{O}_2^- > \text{F}^- > \text{H}_2\text{O} > \text{Cl}^-$  (C).  $\text{Cl}^- > \text{F}^- > \text{C}_2\text{H}_3\text{O}_2^- > \text{H}_2\text{O}$   
(D).  $\text{F}^- > \text{C}_2\text{H}_3\text{O}_2^- > \text{H}_2\text{O} > \text{Cl}^-$  (E).  $\text{F}^- > \text{Cl}^- > \text{H}_2\text{O} > \text{C}_2\text{H}_3\text{O}_2^-$

(背面仍有題目,請繼續作答)

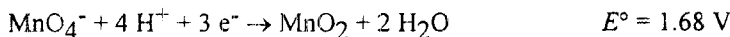
13. Methyl orange is an indicator with a  $K_a$  of  $1 \times 10^{-4}$ . Its acid form, HIn, is red, while its base form,  $\text{In}^-$ , is yellow. At pH 6.0, the indicator will be  
(A). yellow (B). red (C). orange (D). blue (E). green

14. For carbonic acid ( $\text{H}_2\text{CO}_3$ ),  $K_{a1} = 4.30 \times 10^{-7}$  and  $K_{a2} = 5.62 \times 10^{-11}$ . Calculate the pH of a 0.50 M solution of  $\text{Na}_2\text{CO}_3$   
(A). 2.03 (B). 3.33 (C). 9.95 (D). 10.25 (E). 11.97

15. Of energy, work, enthalpy, and heat, how many are state functions?  
(A). 0 (B). 1 (C). 2 (D). 3 (E). 4

16. Consider the gas phase reaction:  $\text{NO} + (1/2)\text{O}_2 \rightleftharpoons \text{NO}_2$ , for which  $H^\circ = -57.0 \text{ kJ}$  and  $K = 1.5 \times 10^6$  at  $25^\circ\text{C}$ . Calculate  $K$  for the following reaction at  $25^\circ\text{C}$ :  $2 \text{NO} + \text{O}_2 \rightleftharpoons 2 \text{NO}_2$   
(A).  $3.0 \times 10^6$  (B).  $2.3 \times 10^{12}$  (C).  $7.5 \times 10^5$  (D).  $1.2 \times 10^3$  (E).  $1.5 \times 10^6$

17. Which of the following is the strongest oxidizing agent?



(A).  $\text{MnO}_4^-$  (B).  $\text{I}_2$  (C).  $\text{Zn}^{2+}$  (D). Zn (E).  $\text{MnO}_2$

18. Which of the following sets of quantum numbers,  $(n, l, m_l, m_s)$ , would NOT be possible for an electron in an atom?

(A). (1, 0, 0, 1/2) (B). (3, 2, -1, -1/2) (C). (4, 4, 1, 1/2)  
(D). (2, 1, 1, -1/2) (E). (6, 1, -1, 1/2)

19. Which of the following bonds would be the most polar without being considered ionic?

(A). Mg-O (B). C-O (C). O-O (D). Si-O (E). N-O

20. What is the hybridization of Xe in the molecule  $\text{XeF}_4$ ?

(A). sp (B).  $\text{sp}^2$  (C).  $\text{sp}^3$  (D).  $\text{dsp}^3$  (E).  $\text{d}^2\text{sp}^3$

21. Which of the following species has the highest bond order?

(A). NO (B).  $\text{CN}^-$  (C).  $\text{O}_2^+$  (D).  $\text{O}_2$  (E).  $\text{O}_2^-$

22. The decomposition of  $\text{N}_2\text{O}_5(\text{g})$  to  $\text{NO}_2(\text{g})$  and  $\text{O}_2(\text{g})$  obeys first-order kinetics.

$$\text{Rate} = - \frac{\Delta[\text{N}_2\text{O}_5]}{\Delta t} = k[\text{N}_2\text{O}_5]. \quad \text{Which of the following will yield a linear plot?}$$

(A).  $[\text{N}_2\text{O}_5]$  vs time (B).  $1/[\text{N}_2\text{O}_5]$  vs time (C).  $\ln[\text{N}_2\text{O}_5]$  vs time  
(D).  $[\text{N}_2\text{O}_5]^2$  vs time (E).  $[\text{NO}_2]$  vs time

23. For the reaction  $\text{A} + \text{B} \rightarrow \text{products}$ , the following data were obtained:

Initial rate (mol/L.s)	0.030	0.059	0.060	0.09	0.090
$[\text{A}]_0$ (mol/L)	0.1	0.2	0.2	0.3	0.3
$[\text{B}]_0$ (mol/L)	0.2	0.2	0.3	0.3	0.5

What is the experimental rate law?

(A).  $\text{Rate} = k[\text{A}]$  (B).  $\text{Rate} = k[\text{B}]$  (C).  $\text{Rate} = k[\text{A}][\text{B}]$   
(D).  $\text{Rate} = k[\text{A}]^2[\text{B}]$  (E).  $\text{Rate} = k[\text{A}][\text{B}]^2$

24. A mineral crystallizes in a cubic closest packed array of sulfur ions ( $\text{S}^{2-}$ ) with aluminum ions ( $\text{Al}^{3+}$ ) in one-half of the octahedral holes and zinc ions ( $\text{Zn}^{2+}$ ) in one-eighth of the tetrahedral holes. What is the formula of this mineral?

(A).  $\text{ZnAlS}_4$  (B).  $\text{ZnAl}_2\text{S}_4$  (C).  $\text{ZnAlS}_2$  (D).  $\text{Zn}_2\text{AlS}_4$  (E).  $\text{ZnAl}_2\text{S}_2$

25. The solubility of  $O_2$  in water is 0.590 g/L at an oxygen pressure of 15 atm. ( $O_2 = 32$ )  
What is the Henry's law constant for  $O_2$  (in units of L-atm/mol)?  
(A).  $3.93 \times 10^{-3}$  (B).  $1.23 \times 10^3$  (C).  $8.14 \times 10^2$  (D).  $1.84 \times 10^{-2}$  (E).  $8.85 \times 10^3$
26. The corrosion of which transition metal results in a characteristic green patina?  
(A). copper (B). chromium (C). iron (D). silver (E). lead
27. Which of the following is paramagnetic?  
(A).  $Zn(H_2O)_6^{2+}$  (B).  $Co(NH_3)_6^{3+}$  (C).  $Fe(CN)_6^{2-}$  (D).  $Cu(H_2O)_6^+$  (E).  $Fe(H_2O)_6^{3+}$
28. What is the final product of the following decays series of  ${}_{90}Th^{230}$ ?  $\alpha, \alpha, \alpha, \beta, \alpha, \beta,$   
(A).  ${}_{84}Po^{218}$  (B).  ${}_{82}Pb^{214}$  (C).  ${}_{84}Po^{210}$  (D).  ${}_{84}Po^{214}$  (E).  ${}_{82}Pb^{218}$
29. A student gave a molecule the following name: 3-methyl-4-isopropylpentane  
However, the teacher pointed out that, although the molecule could be correctly drawn from this name, the name violates the IUPAC rules. What is the correct (IUPAC) name of the molecule?  
(A). 2,3,4-trimethylhexane (B). 2-isopropyl-3-methylpentane  
(C). 1,1,2,3-tetramethylpentane (D). 4-isopropyl-3-methylpentane  
(E). 3,4-dimethylheptane
30. Referring to the structures below, which statement is true?
- $$\begin{array}{c} O \\ || \\ H-C-O-CH_2CH_2OH \end{array}$$

I.

$$HOCH_2CH_2-\begin{array}{c} O \\ || \\ C-OH \end{array}$$

II.

$$HOCH_2CH_2-O-\begin{array}{c} O \\ || \\ C-H \end{array}$$

III.
- (A). I and II have different molecular formulas. (B). I and III are structural isomers of each other.  
(C). II and III are stereoisomers of each other. (D). I and III are the same compound.  
(E). II and III are different conformations of the same compound.
- (單選：31-40 每題 4 分，共 40 分，答錯倒扣 2 分)
31. The density of diatomic gas is 1.696 g/L at STP. Identify the gas. ( $R = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$ ;  $K = 273 + ^\circ\text{C}$ )  
(A).  $H_2$  (MW=2) (B).  $N_2$  (MW=28) (C).  $O_2$  (MW=32) (D).  $F_2$  (MW=38) (E).  $Cl_2$  (MW=70.9)
32. Given the equation:  $2NOCl_2(g) \rightleftharpoons 2NO(g) + Cl_2(g)$ . The equilibrium constant is 0.0150 at  $115^\circ\text{C}$ .  
Calculate  $K_p =$  \_\_\_\_\_ ( $R = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$ ;  $K = 273 + ^\circ\text{C}$ )  
(A). 0.378 (B). 0.478 (C). 0.578 (D). 0.678 (E). 0.778
33. Using Hess's Law and equations 1-3 below, find  $\Delta H^\circ$  at  $25^\circ\text{C}$  for the oxidation of  $C_2H_5OH$  (l).  
 $C_2H_5OH(l) + 3 O_2(g) \rightarrow 3 H_2O(l) + 2 CO_2(g)$   $\Delta H^\circ =$  \_\_\_\_\_ kJ
1.  $C_2H_4(g) + 3 O_2(g) \rightarrow 2 CO_2(g) + 2 H_2O(l)$   $\Delta H^\circ = -1411 \text{ kJ}$
  2.  $C(\text{graphite}) + 3 H_2(g) + (1/2) O_2(g) \rightarrow C_2H_5OH(l)$   $\Delta H^\circ = -278 \text{ kJ}$
  3.  $C_2H_4(g) + H_2O(l) \rightarrow C_2H_5OH(l)$   $\Delta H^\circ = -44 \text{ kJ}$
- (A). -1367 kJ (B). 1367 kJ (C). 1733 kJ (D). -1089 kJ (E). 1089 kJ
34. One mole of an ideal gas is compressed isothermally and reversibly at  $25^\circ\text{C}$  from 2.00 atm to 50.0 atm.  
Calculate the work done by system.  $w =$  \_\_\_\_\_ kJ. ( $R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  $K = 273 + ^\circ\text{C}$ )  
(A). 5.67 kJ (B). 7.98 kJ (C). 8.93 kJ (D). 9.69 kJ (E). 10.89 kJ
35. What is the value of the equilibrium constant at  $25^\circ\text{C}$  for the reaction:  
 $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$   $E^\circ = 2.00 \text{ V}$ ?  $K =$  \_\_\_\_\_  
(A).  $10^{200}$  (B).  $10^{201}$  (C).  $10^{202}$  (D).  $10^{203}$  (E).  $10^{204}$

36. If the energy level of electron in hydrogen atom is  $-\frac{1.629 \times 10^{-18}}{n^2}$  J, what is the shortest wavelength of radiation that can be absorbed in the atomic spectrum? ( $h = 6.626 \times 10^{-34}$  Js, speed of light =  $3 \times 10^8$  m/s)  
(A). 100 nm (B). 112 nm (C). 122 nm (D). 134 nm (E). 146 nm
37. Given the following:  
Li(s)  $\rightarrow$  Li(g) heat of sublimation of Li(s) = 166 kJ/mol  
HCl(g)  $\rightarrow$  H(g) + Cl(g) bond energy of HCl = 427 kJ/mol  
Li(g)  $\rightarrow$  Li<sup>+</sup>(g) + e<sup>-</sup> ionization energy of Li(g) = 520 kJ/mol  
Cl(g) + e<sup>-</sup>  $\rightarrow$  Cl<sup>-</sup>(g) electron affinity of Cl(g) = -349 kJ/mol  
Li<sup>+</sup>(g) + Cl<sup>-</sup>(g)  $\rightarrow$  LiCl(s) lattice energy of LiCl(s) = -829 kJ/mol  
H<sub>2</sub>(g)  $\rightarrow$  2H(g) bond energy of H<sub>2</sub> = 432 kJ/mol  
Calculate the net change in energy for the reaction of  
2 Li(s) + 2 HCl(g)  $\rightarrow$  2 LiCl(s) + H<sub>2</sub>(g)  $\Delta H =$  \_\_\_\_\_ kJ  
(A). -593 kJ (B). -587 kJ (C). -562 kJ (D). -543 kJ (E). -521 kJ
38. Metallic sodium crystallizes in a body-centered cubic lattice. The length of an edge of the unit cell is 0.430 nm. The radius of the sodium atom in this crystal is \_\_\_\_\_ nm.  
(A). 0.186 (B). 0.248 (C). 0.304 (D). 0.372 (E). 0.430
39. What is the real osmotic pressure in atm of a 0.0100 M solution of NaCl in water at 25°C?  
(R = 0.08206 L atm K<sup>-1</sup> mol<sup>-1</sup>, K = 273 + °C)  $\pi =$  \_\_\_\_\_ atm  
(A). 0.1223 (B). 0.2445 (C). 0.367 (D). 0.489 (E). 0.611
40. The Cs-131 nuclide has a half-life of 30 years. After 120 years, about 3 grams remain. The original mass of the Cs-131 sample is closest to \_\_\_\_\_ grams.  
(A). 12.00 (B). 24.00 (C). 36.00 (D). 42.00 (E). 48.00