國立中山大學103學年度轉學考招生考試試題

科目名稱：微積分【化學系二年級】　　題號：722001

※本科目依簡章規定「不可以」使用計算機　　

1.

(a) If $x^2y+y^3=2$ and $y(1)=1$. Find $y'(1)$ and $y''(1)$ by implicit differentiation. [10%]

(b) Find all relative extreme values of $f(x)=2x^3-3x^2-12x+4$. [10%]

2.

(a) Evaluate $\int_0^{\pi/2}\cos^2 x\ \sin x\,dx$. [10%]

(b) Evaluate $\int \frac{x}{x^2+x-2}\,dx$. [10%]

3.

(a) Find the interval of convergence of $\sum_{n=2}^{\infty} n(n-1)(x-1)^n$. [10%]

(b) Find the sum in (a) for x inside the interval of convergence. [10%]

4.

(a) Find the shortest distance from the point $(2,0,1)$ to the plane $x+y+z=1$. [10%]

(b) Find the maximum and minimum values of $f(x,y,z)=2x+y+z+4$ subject to the constraint $x^2+y^2+z^2=6$. [10%]

5.

(a) Evaluate the triple integral $\int\int\int_{\Omega}(x+2z)dV$, where $\Omega=\{(x,y,z)|\,0\le x,\ 0\le y,\ 1\le x^2+y^2+z^2\le 4\}$ [10%]

(b) Evaluate the line integral $\int_C(y\,dx-x\,dy)$, where C is the curve $x=t^2$, $y=e^{t^2}$, $0\le t\le 1$, from $(0,1)$ to $(1,e)$. [10%]

Part I. Multiple Choice (including single choice) (60%)

1. Which statements about bonding molecular orbitals are correct?
   (a) Electrons in bonding orbitals tend to stabilize the molecule.
   (b) Only σ bonds can result from bonding molecular orbitals.
   (c) In a bonding molecular orbital, the electron density is high between the two atoms.
   (d) Bonding molecular orbitals result from *in phase* overlap of the wave functions of the atomic orbitals.
   (e) The relative numbers of electrons in bonding versus antibonding orbitals determine the overall stability of the molecule.

2. Consider the following reaction

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

which would be the appropriate equilibrium constant expression: (single choice)

(a) $\frac{[H_2O]^4}{[H_2]^4}$　(b) $\frac{[H_2]^4}{[H_2O]^4}$　(c) $\frac{[Fe_3O_4][H_2]}{[Fe][H_2O]}$

(d) $\frac{[Fe_3O_4][H_2]^4}{[Fe]^3[H_2O]^4}$　(e) $\frac{[Fe]^3[H_2O]^4}{[Fe_3O_4][H_2]^4}$

3. Nitrogen (atomic mass = 14.0067 amu) has two naturally occurring isotopes. The masses of ^{14}N and ^{15}N are 14.003074 and 15.000108 amu, respectively. What is the percent abundance of ^{15}N?

(a) 15.0001%　(b) 14.0031%　(c) 99.635%　(d) 0.365%　(e) 0.0104%

4. The first ionization energy of sulfur (1005 kJ/mol) is less than that of phosphorus (1060 kJ/mol). Reasonable explanations for this fact involve:

(a) the stability of the half-filled subshell in atomic sulfur.
(b) pairing of two electrons in one 3*p* orbital in sulfur atoms.
(c) the smaller size of sulfur atoms relative to phosphorus atoms.
(d) the electron-electron repulsion cause the fourth *3p* electron in sulfur to be easily removed.
(e) the larger effective nuclear charge Z_{eff} of sulfur atoms

5. What are the number of protons, neutrons, and electrons in the $^{34}_{16}S^{2-}$ ion.
(a) 16 p, 18 n, 16 e　(b) 16 p, 18 n, 14e　(c) 16 p, 16 n, 19 e
(d) 16 p, 18 n, 18 e　(e) 34 p, 16 n, 18 e

6. The second law of thermodynamics states:
(a) The entropy increase for all exothermic processes.
(b) The enthalpy of the universe always increases in spontaneous processes.
(c) A spontaneous process always increases entropy.
(d) $\triangle H < 0$ and $\triangle S > 0$ for all spontaneous processes
(e) The entropy of the universe always increases in spontaneous processes.

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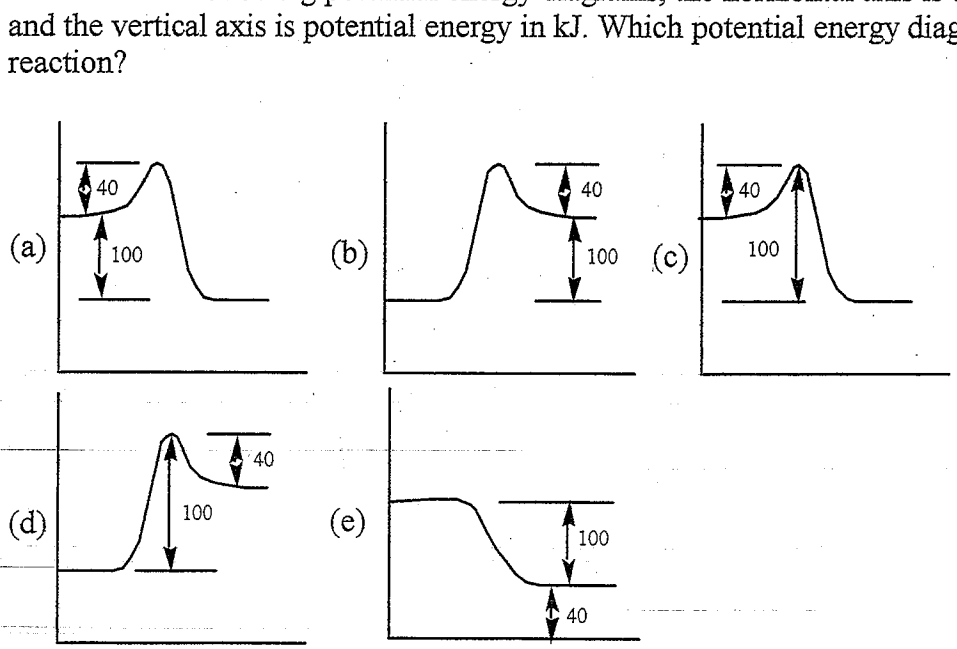
7. Consider CH_4 and CF_4. Electronegativities: C = 2.5, H = 2.1, F = 4.0. Which statement is true?
   (a) Both are sp^3 hybridized at carbon.
   (b) The bond angles in CF_4 are smaller than those in CH_4.
   (c) The C-F bonds are more polar than the C-H bonds.
   (d) Both molecules are nonpolar.
   (e) The bond dipoles in CF_4 are directed toward the fluorine, but those in CH_4 are directed toward the carbon atom.

8. What is the bond order for each of the following species: N_2, N_2^-, N_2^+ and which one would be predicted to have the shortest bond length?

	bond order			shortest bond length
	N_2	N_2^-	N_2^+	
(a)	3	3.5	2.5	N_2^+
(b)	3	2.5	2.5	N_2
(c)	3	4	2	N_2^-
(d)	2	3	1	N_2^-
(e)	3	4	2	N_2^-

9. A catalyst
   (a) increases the amount of products present at equilibrium.
   (b) increases the rate at which equilibrium is reached but decreases the equilibrium constant.
   (c) increases the rate at which equilibrium is reached without changing the equilibrium constant.
   (d) increases $\triangle H$ for the process.
   (e) lowers the activation energy by changing the reaction pathways.

10. A reaction has an activation energy of 40 kJ and an overall energy change of reaction of –100 kJ. In each of the following potential energy diagrams, the horizontal axis is the reaction coordinate and the vertical axis is potential energy in kJ. Which potential energy diagram best describes this reaction?



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11. The gas phase reaction A + B → C has a reaction rate which is experimentally observed to follow the relationship rate = $k[A]^2[B]$. Which one of the following would affect the value of the specific rate constant, k?

(a) increasing the temperature
(b) changing the concentration of A
(c) changing the concentration of B
(d) adding a catalyst
(e) all of the above

12. What volume of 0.1125 M $K_2Cr_2O_7$ would be required to oxidize 48.16 mL of 0.1006 M Na_2SO_3 in acidic solution? The products include Cr^{3+} and SO_4^{2-} ions.

(a) 14.36 mL
(b) 28.75 mL
(c) 43.12 mL
(d) 56.12 mL
(e) 32.15 mL

13. For real gas, it follows $(P + \frac{n^2a}{V^2})(V - nb) = nRT$. Which one of the statements is true?

(a) A real gas behaves more nearly as an ideal gas at high temperatures and low pressures.
(b) In the van der Waals equation, the "a" factor corrects for attractive forces, and one would expect a larger value of "a" for HF than for He.
(c) The "b" factor in the van der Waals equation should be larger for He than for Cl_2.
(d) Gases approach their liquefaction points as temperature decreases and as pressure increases.
(e) Both "a" and "b" of the van der Waals equation have values of zero for an ideal gas.

14. About the surface tension, which statements are true?

(a) The intermolecular interactions among the liquid molecules are responsible for the phenomenon of surface tension.
(b) The molecules at the surface do not have other molecules on all sides of them and therefore are pulled inwards, which creates internal pressure and forces liquid surfaces to contract to the minimal area.
(c) Surface tension can also be thought of as the amount of energy required to increase the surface area of a liquid.
(d) Surface tension is not related to the capillary action.
(e) From the energy point of view, molecules in the surface area are in the lower energy state than molecules in the interior of a liquid.

15. About proteins, which statements are true?

(a) The primary structure is the order of the amino acids, which is crucial to the protein's biological function.
(b) Factors that might affect the tertiary structure of a protein include hydrogen bonds, electrostatic interactions, and hydrophobicity.
(c) α- helix and β- sheet are common secondary structures of proteins.
(d) Heat and pH change can lead to denatured proteins.
(e) The biological functions of proteins are not affected by their tertiary structure.

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16. Consider the following reaction occurring at constant pressure and temperature, for which the value of ΔE is negative. Which statements are true ?

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(l)$$

(a) Work is done by the surroundings on the system.
(b) Work is positive.
(c) Heat is released by the system.
(d) The volume must increase at constant pressure.
(e) The reaction is non-spontaneous..

17. The dissolution process is exothermic if the amount of energy released in bringing about __a__ interactions exceeds the sum of the amounts of energy absorbed in overcoming __b__ and __c__ interactions.

	a	b	c
(a)	solute-solute	solvent-solvent	solvent-solute
(b)	solvent-solvent	solute-solute	solvent-solute
(c)	solvent-solute	solute-solute	crystal lattice
(d)	solute-solute	crystal lattice	solvent-solvent
(e)	solvent-solute	solute-solute	solvent-solvent

18. If the concentration of CO_2 is 2.90 g of CO_2 per 1.00 L of soft drink when bottled under 2.0 atm of CO_2 pressure, what will be the concentration of the CO_2 in the drink after it has been opened and left to come to equilibrium with the atmosphere which has a CO_2 partial pressure of 3.0×10^{-4} atm?

(a) 2.2×10^{-3} g CO_2/L (b) 2.0×10^{-4} g CO_2/L (c) 1.0×10^{-4} g CO_2/L
(d) 4.4×10^{-4} g CO_2/L (e) 4.6×10^{-2} g CO_2/L

19. What is the mass % solute of a 2.00 molal (※ note: not molar) H_2SO_4 solution in water?

(a) 1.1 % (b) 9.8 % (c) 19.6 % (d) 2.0 % (e) 16.4 %

20. Sucrose is a nonvolatile, nonionizing solute in water. Determine the vapor pressure lowering, at 27°C, of a solution of 75.0 grams of sucrose, $C_{12}H_{22}O_{11}$, dissolved in 180.0 g of water. The vapor pressure of pure water at 27°C is 26.7 torr. Assume the solution is ideal.

(a) 0.585 torr (b) 0.058 torr (c) 0.571 torr (d) 5.62 torr (e) 0.548 torr

21. Which of the following statements regarding a 1 *M* sucrose solution is **not** correct?
(a) The boiling point is greater than 100 °C.
(b) The freezing point is lower than that of a 1 *M* NaCl solution.
(c) The freezing point is less than 0.0 °C.
(d) The boiling point is lower than that of a 1 *M* NaCl solution.
(e) The vapor pressure at 100 °C is less than 760 torr.

22. If the van't Hoff factor for NaCl is 1.88, what is the freezing point of a 0.50 molal NaCl solution in water? $K_f = 1.86$°C/*m* for water.

(a) –0.93 °C (b) 1.86 °C (c) –1.75 °C (d) 1.75 °C (e) –1.86 °C

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23. About the color of a coordination compound, which statements are true?

(a) The color of the complex is the sum of the light absorbed by the complex
(b) Besides the types of ligands, the color of a complex also depends on the central metal ion and its oxidation state
(c) It is the energy level of the coordination compound that determines at which wavelength the light can be absorbed
(d) For complexes with more than one d-electron, there could be several absorption bands
(e) Higher oxidation state tends to have larger splitting, therefore altering the color of the complex

24. Which statement regarding the photoelectric effect is correct?

(a) Electrons can be ejected only if the light is of sufficiently short wavelength.
(b) The current increases with increasing intensity of the light.
(c) Electrons can be ejected only if the light is of sufficiently high energy.
(d) The current does not depend on the color of the light as long as the wavelength is short enough.
(e) The wavelength limit sufficient for the ejection of electrons is the same for all metals.

25. The following reaction is partially responsible for acid rain:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Rate data have been determined at a particular temperature for the reaction in which all reactants and products are gases.

Trial Run	Initial [SO_3]	Initial [H_2O]	Initial Rate ($M \cdot s^{-1}$)
1	0.35 *M*	0.35 *M*	0.150
2	0.70 *M*	0.35 *M*	0.600
3	0.35 *M*	0.70 *M*	0.300
4	0.70 *M*	0.70 *M*	1.20

The rate-law expression is _____.

(a) rate = $k[SO_3]^2[H_2O]^2$ (b) rate = $k[SO_3]^2[H_2O]$ (c) rate = $k[SO_3][H_2O]^2$
(d) rate = $k[SO_3]^2$ (e) rate = $k[SO_3][H_2O]$

26. Which statement regarding a stable **heteronuclear** diatomic molecule is true?
(a) The bonding molecular orbitals have more of the character of the more electronegative element than of the less electronegative element.
(b) The antibonding molecular orbitals have more of the character of the more electropositive element than of the more electronegative element.
(c) All have bond orders greater than zero.
(d) Their molecular orbital diagrams are more asymmetrical than those of homonuclear diatomic molecules.
(e) The greater the difference in energy between two overlapping atomic orbitals, the more polar is the bond resulting from the electrons occupying the bonding molecular orbital.

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27. There are two ways that C_4H_{10} can exist. Which of the following statements about these two forms is false?

(a) The two forms have the same boiling point.
(b) The two forms are called constitutional isomers.
(c) The two forms have the same molecular weight.
(d) All carbons in both of the two forms have four bonds.
(e) The two forms are both alkanes.

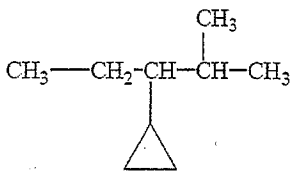
28. Which of the following statements about polyprotic acids is incorrect?

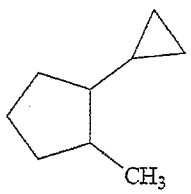
(a) Polyprotic acids can furnish two or more hydronium ions per molecule.
(b) It is generally accepted practice to ignore second or third ionizations when calculating the concentration of H_3O^+.
(c) The ionizations of polyprotic acids occur simultaneously.
(d) Successive ionization constants for polyprotic acids generally decrease.
(e) Phosphoric acid is a typical polyprotic acid

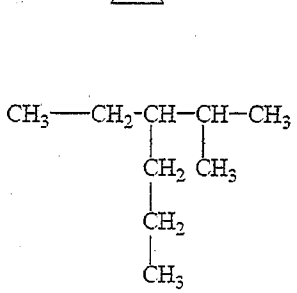
29. Which of the following statements concerning octahedral complexes are correct?

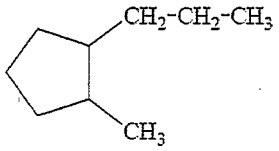
(a) Strong field ligands produce large crystal field splittings.
(b) Weak field ligands produce high spin complexes.
(c) Halide ions are strong field ligands.
(d) Weak field ligands result in relatively small values for Δ_{oct}.
(e) A relatively large value for Δ_{oct} causes a complex ion to absorb light with shorter wavelength.

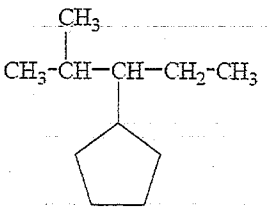
30. Which of the following is the correct structure for 3-cyclopropyl-2-methylpentane?

(a)


(b)


(c)


(d)


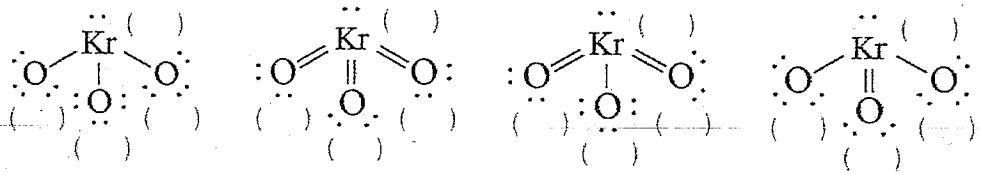
(e)


Part II. Non-choice (40%)

1. (5 %) Following are four of possible Lewis structures for KrO_3.

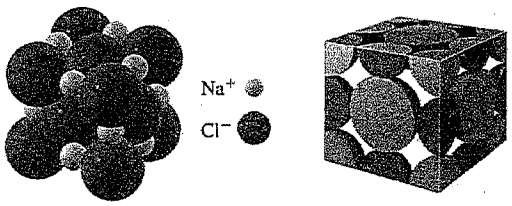
(1) Determine the formal charge of each atom in these four Lewis structures. (4 %)

A. B. C. D.



(2) Which Lewis structure is the most likely structure for XeO_3 (A-D) (1%) ?

2. (10%) For sodium chloride ionic crystal, Na^+ and Cl^- have ionic radius of 1.02 and 1.81 Å, respectively



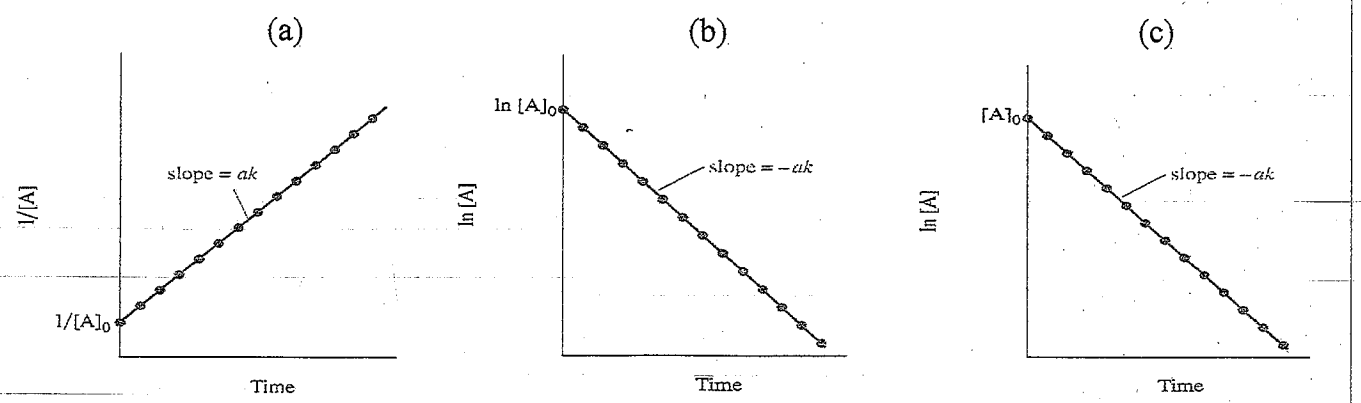
(a) How many Cl^- ions surround a Na^+ ion? (2%)

(b) What is the edge length of each unit cell? (2 %)

(c) What is the shortest distance between two Na^+ ions? (3 %)

(d) What is the space between two nearest Cl^- ions? (3 %)

3. (6 %) For the following graphs, determine their corresponding reaction order:



4. (10%) An electrochemical cell is constructed at 25 °C as follows: One half-cell consists of the Cl_2/Cl^- with a reduction potential of $E^\circ = +1.360$ V, and the other half-cell involves the MnO_4^-/Mn^{2+} in acidic solution with a reduction potential of $E^\circ = +1.507$ V.

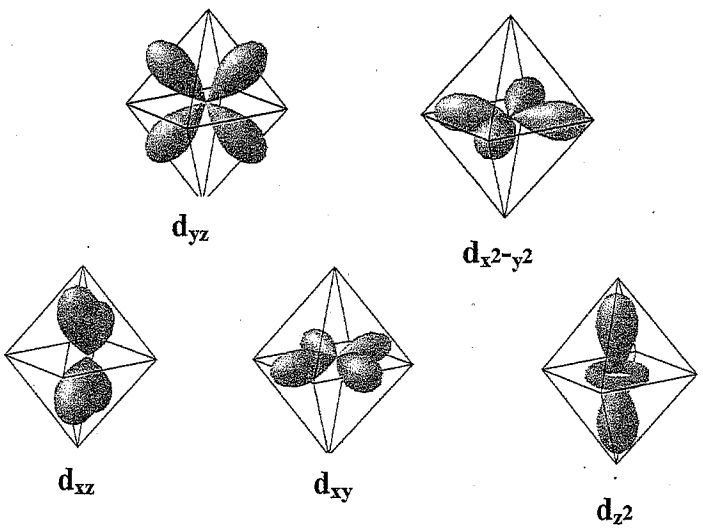
(1) Write down the overall reaction for this electrochemical cell. (2 %)

(2) What is the standard potential for this electrochemical cell ? (2 %)

(3) What is the standard Gibbs free energy change, $\triangle G^\circ$? (3 %)

(4) Calculate the equilibrium constant K at 25°C (3 %)

5. (9 %) Crystal field theory treats the ligands as point charges and considers the effect of these point charges on the relative energies of the d orbitals.
Consider the five d orbitals in an octahedral coordination configuration



(a) Which orbitals point their lobes *directly* at the point-charge ligands, and are classified as e_g orbitals? (2%)

(b) Which orbitals point their lobes *between* at the point-charge ligands, and are classified as t_{2g} orbitals? (2%)

(c) Which set of orbitals are higher in energy (e_g or t_{2g})? Please explain why? (2%)

(d) F^- is a relatively weak ligand, sketch the electron configuration of *d* electrons for $[CoF_6]^{3-}$ and specify the number of unpaired electron (3%)

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