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二、考生應在答案卷上規定範圍內作答，且不得書寫任何與答案無關之文字、符號，違者該科不予計分。

三、答案卷以每人一張為限，不得要求增補；試題與答案卷必須繳回，不得攜出試場。

*可使用工程型計算機

Multiple Choice, choosing the one alternative that best completes the statement or answers the question (4 points each).

1. Which of the following statement in regard to unit conversions is **correct**?

- [A] One kilogram is equal to 10^{-9} teragrams. [B] Twenty-five femtograms are equal to 2.5×10^{-14} kilograms.
[C] Eight liters are equal to 80 cubic decimeters. [D] 294.5 nm are equal to 2.945×10^7 centimeters.
[E] One microliter is equal to 10^{-6} milliliters.

2. Which one of the following statements is **correct**? Assume the acids are dissolved in water.

- [A] The systematic name for H_2SO_4 is hydrosulfuric acid. [B] The systematic name for ICl is iodine chloride.
[C] The systematic name for NH_4NO_3 is nitrogen tetrahydrogen nitrate.
[D] The systematic name for Sr_3N_2 is tristrontium dinitrogen. [E] The systematic name for KClO_3 is potassium chlorite.

3. Which one of the following statements is **correct**?

- [A] The systematic name for TeO_3^{2-} is tellurate ion. [B] The systematic name for Hg_2Cl_2 is mercury chloride.
[C] The systematic name for $\text{Mg}_3(\text{SbO}_4)_2$ is magnesium antimonate.
[D] The systematic name for GaAs is gallium arsenate. [E] The systematic name for Na_2O_2 is sodium oxide.

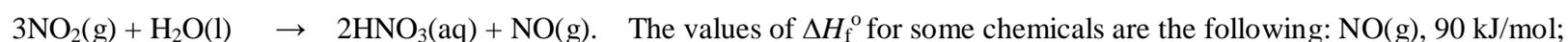
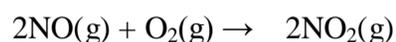
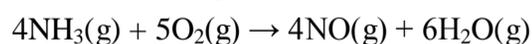
4. A spherical glass container of unknown volume contains helium gas at 25°C and 1.960 atm. When a portion of the helium is withdrawn and adjusted to 1.00 atm at 25°C , it is found to have a volume of 1.75 cm^3 . The gas remaining in the first container shows a pressure of 1.710 atm. The **volume** of the spherical container is _____ L.

- [A] 7×10^{-4} [B] 7×10^{-3} [C] 7×10^{-2} [D] 0.7 [E] 7

5. Which one of the following statements is **correct**?

- [A] For a 1.0-L container of neon gas at STP, its frequency of collision with the container walls will increase when the temperature is decreased to -50°C .
[B] Real gas behaves most ideally when a container volume is relatively small and the gas molecules are moving relatively slow.
[C] For separate 1.0-L gaseous samples of H_2 , Xe, Cl_2 and O_2 all at STP, H_2 has the highest average velocity.
[D] For separate 1.0-L gaseous samples of H_2 and O_2 that all have the same average velocity, O_2 has a lower temperature.
[E] For separate 1.0-L gaseous samples of H_2 , Xe, Cl_2 and O_2 all at STP, Xe has the highest average kinetic energy.

6. The Ostwald process for the commercial production of nitric acid from ammonia and oxygen involves the following steps:



values of ΔH_f° to calculate the value of ΔH° for the last reaction, $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$ to be _____.

- [A] -908 kJ [B] -112 kJ [C] -140 kJ [D] -826 kJ [E] -220 kJ

7. Using the Heisenberg uncertainty principle, please calculate **the Δx** for a baseball (mass = 145 g) with $\Delta v = 0.100$ m/s to be _____.
- [A] 3.64×10^{-4} m [B] 5.79×10^{-4} m [C] 3.64×10^{-33} m [D] 5.79×10^{-33} m [E] 3.64×10^{-18} m
8. Which of the following statements is **correct**?
- [A] Argon has ionization energy higher than bromine. [B] Among Na^- , Na , and Na^+ , Na^- has the smallest radius.
- [C] For Rb, Na, and Be, the order of increasing atomic size is $\text{Rb} < \text{Na} < \text{Be}$.
- [D] In the ground state of mercury, Hg, its electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$.
- [E] In the ground state of element 115, Uup, it has 24 electrons occupying atomic orbitals with $l = 3$.
9. Please use the following data to estimate ΔH_f° for potassium chloride to be _____ kJ/mol.
 $\text{K}(s) + (1/2)\text{Cl}_2(g) \rightarrow \text{KCl}(s)$; lattice energy, -690. kJ/mol; ionization energy for K, 419 kJ/mol; electron affinity of Cl, -349 kJ/mol; bond energy of Cl_2 , 239 kJ/mol; enthalpy of sublimation for K, 90. kJ/mol.
- [A] -161 [B] -1085 [C] 161 [D] 1085 [E] -411
10. Which of the following statements is **correct**?
- [A] F_2^+ has its bond order of 1.5. [B] CN^- is paramagnetic. [C] Between O_2^{2+} and N_2^{2+} , O_2^{2+} would most likely gain an electron.
- [D] The predicted molecular structure and expected hybrid orbitals on the central atom of TeF_4 are see-saw and $d^2 sp^3$, respectively.
- [E] The predicted molecular structure and expected hybrid orbitals on the central atom of IF_4 is trigonal bipyramid and $d^2 sp^3$, respectively.
11. Which of the following statements is **correct**?
- [A] CO_2 has intermolecular forces **greater** than that of OCS . [B] LiF has its freezing point **lower** than those of F_2 and HCl .
- [C] CaO has its enthalpy of fusion **smaller** than those of I_2 and CsBr .
- [D] H_2O_2 has its viscosity **greater** than those of HF and H_2S . [E] H_2CO has intermolecular forces **greater** than that of CH_3OH .
12. Calcium has a cubic closest packed structure as a solid. Assuming that calcium has an atomic radius of 197 pm, please calculate the **density** of solid calcium to be _____ g/cm³
- [A] 11.6 [B] 1.54 [C] 4.5 [D] 3.38 [E] 22.68
13. In order to prepare a solution with a freezing point of -1.50°C , 200.0 g water has to be added glycerin ($\text{C}_3\text{H}_8\text{O}_3$), a nonelectrolyte, with **mass** of _____ g to attain the desired aqueous solution.
- [A] 0.018 [B] 36.46 [C] 18.1 [D] 26.0 [E] 14.8
14. Consider the reaction $3\text{A} + \text{B} + \text{C} \rightleftharpoons \text{D} + \text{E}$ where the rate law is defined as $-(\Delta[\text{A}]/\Delta t) = k[\text{A}]^2[\text{B}][\text{C}]$. An experiment is carried out where $[\text{B}]_0 = [\text{C}]_0 = 1.00$ M and $[\text{A}]_0 = 1.00 \times 10^{-4}$ M. We also know that after 3.00 min of the reaction, $[\text{A}]$ is 3.26×10^{-5} M. What will be **the concentration of A** after 10.0 min?
- [A] 1.27×10^{-5} M [B] 2.5×10^{-6} M [C] 1.00 M [D] 2.50×10^{-5} M [E] 7.90×10^{-5}
15. E_a for the uncatalyzed reaction $\text{O}_3(g) + \text{O}(g) \rightarrow 2\text{O}_2$ is 14.0 kJ. E_a for the same reaction when catalyzed is 11.9 kJ. What is the **ratio** of the rate constant for the catalyzed reaction to that for the uncatalyzed reaction at 25°C ? Assume that the frequency factor A is the same for each reaction.
- [A] 215 [B] 51 [C] 2.3 [D] 532 [E] 0.25
16. Consider the decomposition equation of a compound: $\text{C}_5\text{H}_6\text{O}_3(g) \rightleftharpoons \text{C}_2\text{H}_6(g) + 3\text{CO}(g)$. When a 5.63-g sample of pure $\text{C}_5\text{H}_6\text{O}_3(g)$ was sealed into an otherwise empty 2.50-L flask and heated to 200°C , the pressure in the flask gradually rose to 1.63 atm and remained at that value. The **K** value for this reaction is _____.
- [A] 3.89×10^{-1} [B] 6.74×10^{-6} [C] 8.00×10^{-2} [D] 4.00×10^{-3} [E] 1.20×10^{-9}

17. Which of the following 0.10 M solutions are correctly arranged in order of **most acidic to most basic**?
- [A] HCl > KCl > NH₄Cl > KCN > KOH [B] NH₄Cl > HCl > KCl > KCN > KOH
 [C] NH₄Cl > HCl > KCN > KCl > KOH [D] HCl > NH₄Cl > KCl > KCN > KOH
 [E] HCl > NH₄Cl > KCN > KCl > KOH
18. A 0.15 M solution of a weak acid is 3.0% dissociated. The **K_a** of the acid is calculated to be _____.
- [A] 3.5×10^{-4} [B] 4.2×10^{-3} [C] 1.4×10^{-4} [D] 2.4×10^{-2} [E] 3.6×10^{-3}
19. Two drops of indicator HIn ($K_a = 1.0 \times 10^{-9}$), where HIn is yellow and In⁻ is blue, are placed in 100.0 mL of 0.10 M HCl. The solution is titrated with 0.10 M NaOH. At what **pH** will the color change (yellow to greenish yellow) occur?
- [A] 7.0 [B] 8.5 [C] 9.0 [D] 7.5 [E] 8.0
20. The **solubility** of Fe(OH)₃ ($K_{sp} = 4 \times 10^{-38}$) in a solution buffered at pH = 5.0 is _____ mol/L
- [A] 4.0×10^{-11} [B] 2.5×10^{-10} [C] 2.5×10^{-4} [D] 4.0×10^{-29} [E] 4.0×10^{-17}
21. Which of the following statements is **correct**?
- [A] For HCl(g) → H⁺(aq) + Cl⁻(aq), its ΔS° is **larger** than 0 (> 0) [B] The S° of C_{graphite}(s) is **larger** than the S° of C_{diamond}(s)
 [C] One mol H₂ (at STP) has **more** positional probability than 1 mol H₂ at 100 K, 0.5 atm.
 [D] The sign of ΔS_{surr} for the process of I₂(g) → I₂(s) is **negative (-)**.
 [E] At constant T and P, the change with $\Delta H = +25$ kJ, $\Delta S = +100$ J/K, $T = 300$. K is **not** a spontaneous process.
22. Consider the following reaction at 25°C: 2NO₂(g) \rightleftharpoons N₂O₄(g). The values of ΔH° and ΔS° are -58.03 kJ/mol and -176.6 J/K • mol, respectively. Assuming ΔH° and ΔS° are temperature independent, estimate the value of **K** at 100.0°C.
- [A] 3.00×10^6 [B] 1.47×10^{-87} [C] 8.72 [D] 7.89×10^{-2} [E] 5.9×10^{15}
23. An unknown metal M is electrolyzed. It took 74.1 s for a current of 2.00 A to plate out 0.107 g of the metal from a solution containing M(NO₃)₃. The **metal** is therefore identified as _____.
- [A] aluminum [B] cobalt [C] bismuth [D] lead [E] gallium
24. The atomic mass of ¹H is 1.00782 amu and the mass of a neutron is 1.00866 amu. **The binding energy** for uranium-235 (atomic mass 235.0439 u) is calculated to be _____ J/nucleon.
- [A] 1.22×10^{-11} [B] 1.22×10^{-12} [C] 1.22×10^{-13} [D] 1.47×10^{-12} [E] 1.47×10^{-11}
25. When proteins in solution are heated, the hydrogen bonds in proteins may be broken to result in collapsing of protein secondary structures. What will be the **effects** of the heating process **on ΔH and ΔS** of the proteins?
- [A] ΔH and ΔS all will increase. [B] ΔH and ΔS all will decrease. [C] ΔH will increase but ΔS will decrease.
 [D] ΔH will decrease but ΔS will increase [E] Both ΔH and ΔS will not change.

Physical Constants

Constant	Symbol	Value
Atomic mass unit	amu	1.66054×10^{-27} kg
Avogadro's number	N	6.02214×10^{23} mol ⁻¹
Bohr radius	a_0	5.292×10^{-11} m
Boltzmann constant	k	1.38066×10^{-23} J/K
Charge of an electron	e	1.60218×10^{-19} C
Faraday constant	F	96,485 C/mol
Gas constant	R	8.31451 J/K · mol
Mass of an electron	m_e	9.10939×10^{-31} kg
Mass of a neutron	m_n	1.67493×10^{-27} kg
Mass of a proton	m_p	1.67262×10^{-27} kg
Planck's constant	h	6.62608×10^{-34} J · s
Speed of light	c	2.99792458×10^8 m/s

The Periodic Table

Period	1	2	3	4	5	6	7	8	9	10	11	12	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
1	H 1.008	He 4.003																
2	Li 6.941	Be 9.012											B 10.81	C 12.01	N 14.01	O 16.00	F 19.00	Ne 20.18
3	Na 22.99	Mg 24.30											Al 26.98	Si 28.09	P 30.97	S 32.07	Cl 35.45	Ar 39.95
4	K 39.10	Ca 40.08	Sc 44.96	Ti 47.88	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.39	Ga 69.72	Ge 72.61	As 74.92	Se 78.96	Br 79.90	Kr 83.80
5	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 98.91	Ru 101.1	Rh 102.9	Pd 106.4	Ag 107.9	Cd 112.4	In 114.8	Sn 118.7	Sb 121.8	Te 127.6	I 126.9	Xe 131.3
6	Cs 132.9	Ba 137.3	La-Lu 178.5	Hf 178.5	Ta 180.9	W 183.8	Re 186.2	Os 190.2	Ir 192.2	Pt 195.1	Au 197.0	Hg 200.6	Tl 204.4	Pb 207.2	Bi 209.0	Po 210.0	At 210.0	Rn 222.0
7	Fr 223.0	Ra 226.0	Ac-Lr	Unq	Unp	Unh	Uns	Uno	Une								

s block	d block	p block
	Lanthanides	
	Actinides	
	f block	