

國立高雄大學 101 學年度研究所碩士班招生考試試題

科目：普通化學
 考試時間：100 分鐘

系所：應用化學系
 本科原始成績：100 分

是否使用計算機：是

hydrogen 1 H 1.0079																	helium 2 He 4.0026	
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180	
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948	
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	unnilium 110 Uun [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]	ununquadium 114 Uuq [289]					

* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [268]	nobelium 102 No [269]

** Actinide series

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Mass of electron: 9.11×10^{-31} kg, Mass of proton= 1.67×10^{-27} kg, $R=0.08206$ L atm mol⁻¹K⁻¹, 8.3145 J K⁻¹ mol⁻¹, $V_{\text{sphere}}=4/3\pi r^3$,

$h = 6.626 \times 10^{-34}$ J s or 6.626×10^{-34} kg m²/s, Neutron mass= 1.67×10^{-27} kg; $\lambda=h/mv$; $\Delta E =$ energy level of n_{final} - energy level n_{initial} ; $E = -2.178 \times 10^{-18}$ J (Z^2/n^2); $C = v \lambda$; $E = hc/ \lambda$; $KE_{\text{electron}}=1/2 mv^2$; $\Delta x \cdot \Delta p \geq \hbar/2$
 $\hbar=h/2\pi$: F=96485 C, Cr mass=52.00 g/mol, Electron mass= 9.10939×10^{-31} kg

Directions: Select the best answer.

1. Which of the following is **not** determined by the principal quantum number, n , of the electron in a hydrogen atom?

- a) the energy of the electron
- b) the minimum wavelength of the light needed to remove the electron from the atom.
- c) the size of the corresponding atomic orbital(s)
- d) the shape of the corresponding atomic orbital(s)
- e) All of the above are determined by n .

2. Which of the following statements is **true** about p -type silicon?

- a) It is produced by doping Si with P or As.
- b) Electrons are the mobile charge carriers.
- c) It does not conduct electricity as well as pure Si.
- d) All are true.
- e) None is true.

3. For which of the following compound(s) are *cis* and *trans* isomers possible?

- a) 2,3-dimethyl-2-butene
- b) 3-methyl-2-pentene
- c) 4,4-dimethylcyclohexanol
- d) ortho-chlorotoluene
- e) All can exhibit *cis/trans* isomers.

4. How many electrons can be described by the quantum numbers $n = 3$, $l = 3$, $m_l = 1$?

- a) 0
- b) 2
- c) 6
- d) 10
- e) 14

5. The net number of face-centered atoms contained in a face-centered cubic unit cell is

- a) 1
- b) 3
- c) 4
- d) 6
- e) none of these

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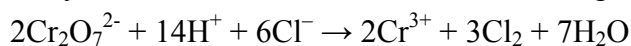
6. Which of the following molecules has a dipole moment?

- a) CF_4 b) SF_4 c) XeF_4
d) All of the above have a dipole moment.
e) None of the above (a-c) has a dipole moment.

7. The first electron affinity value for oxygen is _____ and the second electron affinity value is _____.

- a) unfavorable (endothermic), favorable (exothermic)
b) unfavorable (endothermic), unfavorable (endothermic)
c) favorable (exothermic), favorable (exothermic)
d) favorable (exothermic), unfavorable (endothermic)
e) More information is needed.

8. How many electrons are transferred in the following reaction?



- a) 2 b) 4 c) 6 d) 8 e) none of these

9. In which of the following cases must E be equal to zero?

- a) In any cell at equilibrium. b) In a concentration cell.
c) E can never be equal to zero. d) Choices a and b are both correct.
e) Choices a, b and c are all correct.

10. For a spontaneous endothermic process, which conditions must hold?

- 1) $w_{\max} = \Delta G$ 2) $\Delta S_{\text{surr}} > 0$
3) ΔS cannot be negative. 4) ΔS is positive.

- a) All are true. b) None are true. c) 1 and 3 d) 1, 2, and 4
e) 3 and 4

11. What is the most abundant element found in the human body?

- a) carbon b) hydrogen c) calcium d) oxygen e) water

12. What is the advantage of a nickel-cadmium or a lead-acid battery?

- a) They have high output voltages b) They are rechargeable
c) They provide high charge to mass ratios d) They are easily disposed of

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e) All are true.

13. Which form of electromagnetic radiation has the shortest wavelengths?

- a) gamma rays b) microwaves c) radio waves
d) infrared radiation e) x-rays

14. Which of the following is optically active?

- a) $\text{HN}(\text{CH}_3)_2$ b) CH_2Cl_2 c) 2-chloropropane
d) 2-chlorobutane e) 3-chloropentane

15. Teflon is an example of a

- a) copolymer b) homopolymer c) dimer
d) two of these e) none of these

16. The Haber process

- a) is used to manufacture ammonia.
b) transforms nitrogen to other nitrogen-containing compounds.
c) is used to recover sulfur from underground deposits.
d) is used to produce nitric acid.
e) none of these

17. When a metal complex ion forms in solution, what are the metal ion and ligands acting as?

- a) The metal ion acts as a Lewis base, and the ligand acts as a Lewis acid.
b) The metal ion is a Lewis acid, and the ligand is its conjugate base.
c) The ligand is a Lewis base, and the metal ion is its conjugate acid.
d) The metal ion acts as a Lewis acid, and the ligand acts as a Lewis base.
e) None of these

18. Which of the following is paramagnetic?

- a) H_2 b) B_2 c) C_2 d) N_2 e) At least two of the above are paramagnetic.

19. What is the hybridization of Cl in the molecule ClF_3 ?

- a) sp b) sp^2 c) sp^3 d) dsp^3 e) d^2sp^3

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20. Why would the

be likely to be radioactive?

- a) The nucleus has an unusually light nucleus and is unstable.
- b) The nucleus is an unusually heavy nucleus and is unstable.
- c) The nucleus has an odd number of both protons and neutrons.
- d) The nucleus has too many neutrons based on the number of protons.
- e) The nucleus does not have a magic number of either protons or neutrons.

21. What is the shape of the ICl_5 molecule?

- a) square pyramid
- b) trigonal bipyramid
- c) octahedral
- d) see-saw
- e) none of these

22. As indicated by Lewis structures, which of the following species could probably not exist as a stable molecule?

- a) NH_3
- b) N_2H_2
- c) N_2H_4
- d) N_2H_6
- e) N_2O_4

23. Which of the following statements is *true*?

- a) The exact location of an electron can be determined if we know its energy.
- b) An electron in a 2s orbital can have the same n , l , and m_l quantum numbers as an electron in a 3s orbital.
- c) Ni has 2 unpaired electrons in its 3d orbitals.
- d) In the buildup of atoms, electrons occupy the 4f orbitals before the 6s orbitals.
- e) Only three quantum numbers are needed to uniquely describe an electron.

24. Which of the following statements is (are) *true*?

- I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
 - II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
 - III. The energy of electromagnetic radiation increases as its frequency increases.
 - IV. An electron in the $n = 4$ state in the hydrogen atom can go to the $n = 2$ state by emitting electromagnetic radiation at the appropriate frequency.
 - V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
- a) I, II, III
 - b) II, III, IV
 - c) I, II, IV
 - d) III, V
 - e) III, IV, V

25. For which of the following diatomic molecules would the bond order become greater if an

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electron is removed, i.e., if the molecule is converted to the positive ion in its ground state?

- a) B₂ b) C₂ c) F₂ d) Na₂ e) P₂

26. The complex ion NiCl₄²⁻ is tetrahedral. The number of unpaired electrons in the complex is:

- a) 0 b) 1 c) 2 d) 3 e) 4

27. What is the density of a hydrogen atom? Assume the radius of the hydrogen atom is 5.0×10^{-9} m.

- A. 0.4 g/cm³
 B. 0.40 g/cm³
 C. 3.2 g/cm³
 D. 3.2×10^{-6} g/cm³
 E. 3.2×10^{-2} g/cm³

28. Which one is the correct systematic name for NaOCl?

- A. Sodium perchlorate
 B. Sodium chlorate
 C. Sodium chloric acid
 D. Sodium hypochlorate
 E. Sodium hypochlorite

29. Which compound(s) have the wrong formula?

1	sodium oxide	NaO
2	sodium peroxide	NaO ₂
3	diphosphorus pentoxide	P ₂ O ₅
4	copper(II) nitrate	Cu(NO ₃) ₂
5	silicon tetrachloride	SiCl ₄

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6	lead(II) oxide	PbO ₂
7	copper(I) chloride	CuCl
8	gallium arsenide	Ga ₂ As ₂
9	cadmium selenide	CdSe
10	zinc sulfide	ZnS ₂

- A. All are correct
- B. All are incorrect
- C. 1,2,6,8 are incorrect
- D. 1,2,6,8,10 are incorrect
- E. 1,2,3,6,7,8,10 are incorrect

30. A single molecule has a mass of 7.31×10^{-23} g. Select an example from the list below of a molecule that can have this mass.

- A. HF
- B. N₂O
- C. O₂
- D. HCN
- E. HCl

31. An element X has five major isotopes, which are listed below with their natural abundances.

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Identify the element.

Isotope	Percent Natural Abundance	Mass (amu)
^{46}X	8.00%	45.95269
^{47}X	7.3%	46.951764
^{48}X	73.8%	47.947947
^{49}X	5.5%	48.947841
^{50}X	5.4%	49.944792

- A. Sn
- B. In
- C. Cd
- D. Cr
- E. Ti

32. Chloral hydrate = $(\text{C}_2\text{H}_3\text{Cl}_3\text{O}_2)$ is a drug formerly used as a sedative and hypnotic. What mass of chloral hydrate would contain 1 g Cl?

- A. 165.39 g
- B. 3.023 g
- C. 5.5×10^{22} g
- D. 1.6 g
- E. 1.373×10^{-19} g

33. Calculate the percent composition by mass of $\text{C}_{20}\text{H}_{29}\text{FO}_3$.

- A. C: 71.40 %, H: 8.689%, F= 5.684%, O=14.27 %
- B. C: 8.689%, H: 71.40 %, F= 5.684%, O=14.27 %
- C. C: 71.40 %, H: 5.684%, F=8.689%, O=14.27 %
- D. C: 14.27 %, H: 5.684%, F= 5.684%, O=71.40 %
- E. C: 71.40 %, H: 8.689%, F= 14.27 %, O=5.684%

34. Natural rubidium has the average mass of 85.4678 and is composed of isotopes ^{85}Rb (mass=84.9117) and ^{87}Rb . The ratio of $^{85}\text{Rb}/^{87}\text{Rb}$ in natural rubidium is 2.591. Calculate the

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mass of ^{87}Rb .

- A. 85.47 amu
- B. 86.92 amu
- C. 84.91 amu
- D. 85.47 amu
- E. 85.18 amu

35. A sample of a hydrocarbon contains 4.26×10^{23} atoms of hydrogen and is 36.95% hydrogen by mass. If the molecular mass of the hydrocarbon is between 55 and 65 g/mol, what is the mass of the sample?

- A. 2.50 g
- B. 2.25 g
- C. 41.1 g
- D. 29.1 g
- E. 40.9 g

36. A 9.780 g gaseous mixture contains ethane (C_2H_6) and propane (C_3H_8). Complete combustion to form carbon dioxide and water requires 1.120 mol of oxygen. Calculate the mass percent of ethane in the original mixture given.

- A. 8%
- B. 18%
- C. 28%
- D. 38%
- E. 58%

37. A mixture contains only sodium chloride and potassium chloride. A 0.3568 g sample of the mixture was dissolved in water. It took 46.55 mL of 0.1100 M AgNO_3 to completely precipitate all the chloride present. What is the composition (by mass percent) of the mixture?

- A. 67.5 % KCl, 32.5 % NaCl
- B. 74.8 % KCl, 25.2 % NaCl
- C. 89.5 % KCl, 10.5% NaCl
- D. 50 % KCl, 50 % NaCl
- E. 55 % KCl, 45 % NaCl

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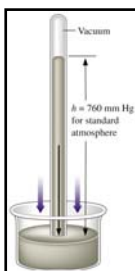
38. A mixture contains only NaCl and $\text{Al}_2(\text{SO}_4)_3$. A 1.45 g sample of the mixture is dissolved in water and an excess of NaOH is added, producing a precipitate of $\text{Al}(\text{OH})_3$. The precipitate is filtered, dried, and weighed. The mass of the precipitate is 0.107 g. What is the mass of $\text{Al}_2(\text{SO}_4)_3$ in the sample? ($\text{Al}_2(\text{SO}_4)_3 = 342.17 \text{ g/mol}$)

- A. 0.699 g
- B. 0.245 g
- C. 0.231 g
- D. 0.123 g
- E. 0.235 g

39. Reaction of 19.0 g of zinc with excess silver nitrite to produce silver metal and zinc nitrite. The reaction is stopped before all the zinc metal has reacted and 29.0 g of solid metal is present. Calculate the mass of each metal in the 29.0 g mixture.

- A. 11.6 g Zn, 10.4 g Ag
- B. 12.6 g Zn, 11.4 g Ag
- C. 13.6 g Zn, 12.4 g Ag
- D. 14.6 g Zn, 14.4 g Ag
- E. 15.6 g Zn, 13.4 g Ag

40. What is the correct name for what is in the picture below/



- A. a manometer
- B. a torricellian barometer
- C. a torr meter
- D. a mecury tube
- E. a Galileo thermometer

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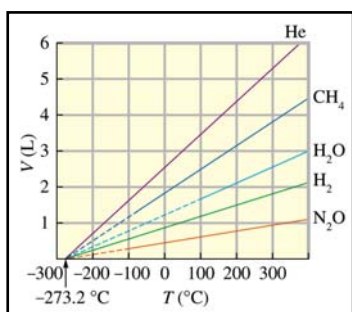
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41. Use the following diagrams to select the best answer to the following question.

In the figure V vs T, why is each gas at a different volume?

Boyle's law: $V = \frac{k}{P}$ (at constant T and n)
 Charles's law: $V = bT$ (at constant P and n)
 Avogadro's law: $V = an$ (at constant T and P)



- A. because the gases are at different pressures
- B. because the gases are at different temperatures
- C. because of Boyles law
- D. because of Charles's law
- E. because of Avogadro's law

42. In a mixture of the two gases, the partial pressures of $\text{CH}_4(\text{g})$ and $\text{O}_2(\text{g})$ are 0.225 atm and 0.320 atm, respectively. Calculate the number of grams of O_2 in the mixture. When $T=70\text{ C}$, Volume=13.5 L

- A. 4.90 g O_2
- B. 3.90 g O_2
- C. 3.03 g O_2
- D. 3.20 g O_2
- E. 5.21 g O_2

43. A compound contains only nitrogen and hydrogen and is 87.4% nitrogen by mass. A gaseous sample of the compound has a density of 0.857 g/L at 690 torr and 100 °C. What is the *empirical* formula of the compound?

- A. N_2H_4
- B. NH_2
- C. NH

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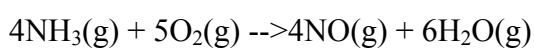
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- D. N_4H_8
- E. N_8H_{16}

44. A flask has two sides separated by a stopcock. What is the total pressure (in torr) in the flask when the stopcock is opened? One side of the flask contains 2.00 L H_2 at 475 torr, and the other side of the flask contains 1.00 L N_2 at 0.200 atm.

- A. 0.333 torr
- B. 368 torr
- C. 568 torr
- D. 669 torr
- E. 421 torr

45. 1 mole of oxygen gas and 2 moles of ammonia are placed in a container and allowed to react at 850 degrees Celsius according to the equation:



If the total pressure in the container is 5.00 atm, what are the partial pressures for the three gases remaining?

- A. $P_{NH_3} = 1.875$ atm, $P_{NO} = 1.25$ atm, $P_{H_2O} = 1.875$ atm
- B. $P_{NH_3} = 3.875$ atm, $P_{NO} = 2.25$ atm, $P_{H_2O} = 1.875$ atm
- C. $P_{NH_3} = 6.875$ atm, $P_{NO} = 1.25$ atm, $P_{H_2O} = 1.875$ atm
- D. $P_{NH_3} = 1.875$ atm, $P_{NO} = 6.875$ atm, $P_{H_2O} = 1.875$ atm
- E. $P_{NH_3} = 4.875$ atm, $P_{NO} = 1.25$ atm, $P_{H_2O} = 5.00$ atm

46. A sample of methane (CH_4) gas contains a small amount of helium. Calculate the volume percentage of helium if the density of the sample is .7092 g/L at 0.0 °C and 1.000 atm.

- A. 98.84% CH_4 , 1.16% He
- B. 97.84% CH_4 , 2.16% He
- C. 96.84% CH_4 , 3.16% He
- D. 95.84% CH_4 , 4.16% He
- E. 99.84% CH_4 , 0.16% He

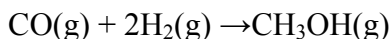
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47. Methanol can be produced by the following reaction



Hydrogen at STP flows into a reactor at a rate of 16.0 L/min. Carbon monoxide at STP flow into the reactor at a rate of 25.0 L/min. If 5.30 g of methanol is produced per minute, what is the percent yield of the reaction?

- A. 40.5%
- B. 41.5%
- C. 42.5%
- D. 43.5%
- E. 46.5%

48. An electron in a one-dimensional box requires a wavelength of 280 nm to excite an electron from the $n=2$ to the $n=3$ energy level. **Calculate the length of this box.**

- A. 100.5 nm
- B. 39.5 nm
- C. 0.65 nm
- D. 3.50 nm
- E. 0.25 nm

49. Which of the following sets of quantum numbers are not allowed in the hydrogen atom?

- I. $n=3, L=2, m_L=2$
- II. $n=4, L=3, m_L=4$
- III. $n=0, L=0, m_L=0$
- IV. $n=2, L=-1, m_L=1$

- A.) I and II
- B.) II and III and IV
- C.) I and IV
- D.) I only
- E.) None are allowed

50. Suppose we have a pink solution containing an unknown concentration of $\text{Co}^{2+}(\text{aq})$ ions. A sample of this solution is placed into a spectrophotometer, and the absorbance is measured at a

國立高雄大學 101 學年度研究所碩士班招生考試試題

科目：普通化學
考試時間：100 分鐘

系所：應用化學系
本科原始成績：100 分

是否使用計算機：是

wavelength where ϵ for Co^{2+} (aq) is known to be $12 \text{ L mol}^{-1}\text{cm}^{-1}$. The absorbance A is found to be 0.60. The width of the sample tube is 1.0 cm. Calculate the concentration of Co^{2+} in the unknown pink solution.

- A. 7.2 mol/L
- B. 0.030 mol/L
- C. 0.050 mol/L
- D. 2.6 mol/L
- E. 20 mol/L