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Final Exam A 第一考场

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Final Exam A 2020

1) What is an appropriate technical term that each of the following phrases (a) - (e) indicates?

Choose the term from those given in a box and answer using its tag. (5x5 = 25points)

(a) The elements in groups 1 and 2 of the periodic table. ☐

(b) The elements in groups 3-12 of the periodic table. ☐

(c) One of the seven SI base units showing amount of substance. ☐

(d) The energy change accompanying the attachment of an electron to an atom or anion. ☐

(e) The requirement that no two electrons in a chemical species can be described by the same set of four quantum numbers. ☐

A. d-block elements	B. p-block elements	C. s-block elements	D. mole
E. electronegativity	F. Aufbau principle	G. Kelvin	H. electron affinity
I. Hunt's rule	K. ionization potential	L. Pauli exclusion principle	

2) Answer the following questions about molecule **A**. (25 points)

A

a) Calculate the molecular mass of **A** and give the answer to the correct number of significant figures. Use the following relative atomic mass: C = 12.01. H = 1.008. (5 points)

b) Calculate the amount (mole) of 10.0 g of **A** and give the answer to the correct number of significant figures with unit. (5 points)

c) There are three other non-cyclic isomers of **A**. Draw their line structures and give their names (3x5 = 15points)

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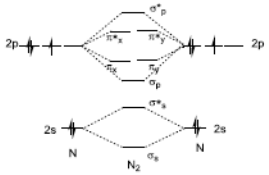
3) Answer the following questions about nitrogen atom ($_7$N) and molecular nitrogen (N_2). (25 points)

(a) Give the ground-state electronic configuration of nitrogen atom using spectroscopic notation. (5 points)

(b) How many valence electrons does nitrogen atom have? (5 points)

(c) The following figure shows the schematic presentation of molecular orbitals (MOs) of N_2 but it is not yet completed. Add electrons with arrows in the figure to complete the MO diagram. (5 points)



(d) Estimate the bond order of the N-N bond of N_2 using the above MO diagram and give the basis. (5 points)

(e) Applying a similar MO diagram for molecular oxygen, estimate its bond order. Answer with the reason. (5 points)

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4) (total 25 points) (a) Calculate the average molar mass of air, which is assumed to behave as an ideal gas containing 79.0% N_2, 20.0% O_2, and 1.0% Ar. Use 14.0, 16.0, and 40.0 for relative atomic masses of N, O, and Ar, respectively. (15 points)

(b) How much is the pressure of the 1.00 kg of air confined in the container of 0.83145 m^3 at 289 K? (10 points)

5) (total 25 points) (a) Define Gibbs energy, G, in terms of enthalpy and entropy. (7 points)

(b) When the chemical reaction,

$$A + B = C$$

is at the chemical equilibrium, write the expression for equilibrium constant, K in terms of the activities of A, B, and C, a_A, a_B, and a_C, respectively. (8 points)

(c) When the standard Gibbs energy of the chemical reaction above is ΔG_r^0, how is this quantity correlated with the equilibrium constant? (10 points)

6) (total 25 points) (a) Illustrate the concept of solubility product for an example of the solubility of AgCl in water. (10 points)

(b) What is the concentration of Ag^+ when the value of the solubility product of AgCl is given and the activity coefficients of the relevant species are all unity? (8 points)

(c) Derive an expression to calculate the concentration of Ag^+ when KCl is added to a solution saturated with AgCl so that the final concentration of K^+ is 0.1 mol dm^{-3}. (7 points)

7) (total 25 points) (a) Consider the following reaction, which is the first order with respect to A,

$$A \rightarrow P$$

Write an expression for the rate of this chemical reaction, - d[A]/dt, where [A] is the concentration of A and t is time. (10 points)

(b) Integrate the above equation to obtain the rate law for this reaction. (8 points)

(c) Express the half-life of A in terms of the rate constant defined above. (7 points)

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8) Answer the following questions.

(a) Write the chemical symbols of transition metals. [1 × 9 = 9]

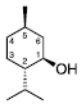
(a) titanium		(b) zirconium		(c) hafnium	
(d) chromium		(e) molybdenum		(f) tungsten	
(g) copper		(h) silver		(i) gold	

(b) Write the coordination number and oxidation state of the transition metal in each complex. [2 × 8 = 16]

entry	complex	coordination number	oxidation state
(a)	$[Mn(CO)_5Cl]$		
(b)	$[Co(OH_2)_6]Cl_2$		
(c)	$[Ni(CO)_4]$		
(d)	$K[AuCl_4]$		

9) Answer the following questions.

(a) Assign an *R* or *S* configuration to the stereocenters at C1, C2 and C5 positions of (–)-menthol. [5 × 3 = 15]

(–)-menthol	C1	C2	C5
			

(b) The specific rotation $[\alpha]_D$ of pure (–)-menthol is –50°. Calculate the optical purity (%) of menthol that shows a specific rotation of –20°. [5]

(c) Calculate the ratio of (–)-menthol to (+)-menthol in the mixture of (b). [5]

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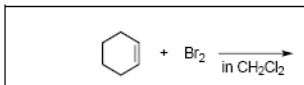
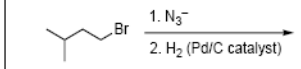
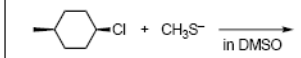
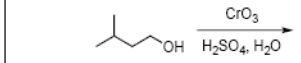
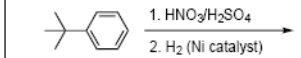
10) Answer the following questions.

(a) Pentane and butan-1-ol have comparable molecular masses, but the boiling point of pentane (36 °C) is much lower than that of butan-1-ol (117 °C). Explain this large difference in boiling points. [12]

(b) The melting points of white phosphorus is 44.1 °C. In contrast, red phosphorus remains a solid up to 400 °C. Explain this large difference in melting points. [13]

11) Draw the structure of the major product of each reaction. [5 × 5 = 25]

	A
	B
	C
	D
	E

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12) Answer the following questions about Grignard reagents and their reactions:

(a) Phenylmagnesium bromide (PhMgBr) can be prepared by the reaction of bromobenzene and magnesium in diethyl ether but not in water or hexane. Explain why the latter two solvents cannot be used for the preparation of PhMgBr within 100 words. (10 points)

(b) Show the polarity of the C–Mg bond of Ph–MgBr using δ+ and δ- symbols. (5 points)

(c) The reaction of PhMgBr with acetone followed by the hydrolysis gives an alcohol in a high yield. Give the structure of the alcohol. (10 points)

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