General Chemistry

IJSO Theory mock test

Answer sheet

Problem 1. Chemistry in a Tea Shop (3.00 points)

Part A. Tea Shop Thermochemistry (1.50 points)

A1. Calculate the molar enthalpy of solution (H_{sol}) of glucose in kJ/mol based on the observation.

(0.75 points)

Calculation:

H_{sol} =

A2. Find the molality of the glucose solution Ravi prepared

(0.25 points)

Calculation:

m =

A3. If Ravi's solution freezes at $-0.52℃$, find the cryoscopic constant of water.

(0.50 points)

$K_f =$

Part B. The Chemistry of Acidity in Tea (0.50 points)

B1. Assuming tannic acid is a monoprotic weak acid with a Ka value of 4×10^{-6}, calculate the pH of the solution at 0.0010 mol/L.

(0.50 points)

Calculation:

pH =

Part C. Tea Sugar Sweetening (1.00 points)

C1. Calculate the mass of sugar Ravi needs to add.

(0.30 points)

Calculation:

Part C1 continuation:

Mass of sugar =

C2. If Ravi adds only 50 g of sugar, what will be the molar concentration of the sugar in the tea?

(0.70 points)

Calculation:

Molar concentration =

Extra space for problem 1:

Problem 2. Identification of Compounds (10.00 points)

Part A. Formula of a Salt (3.35 points)

A1. Identify substances **A**, **B**, **C** and **D**

(1.80 points)

Calculation:

Chemical formulas:

A = ……..

B = ……..

C = ……..

D = ……..

A2. Write the balanced equations of reactions 1, 2 and 3

(0.75 points)

Reaction 1:

Reaction 2:

Reaction 3:

A3. For each of the substances specify if it's ionic, covalent polar or covalent nonpolar

(0.60 points)

Tick the right answer:

	Ionic	Covalent Polar	Covalent Nonpolar
Compound A			
Compound B			
Compound C			
Compound D			

Part B. Substances Taking Part in a Redox Reaction (6.65 points)

B1. Write the chemical formulas of compounds A-G

(2.75 points)

Chemical formulas:

A = ……..

B = ……..

C = ……..

D = ……..

E = ……..

F = ……..

G = ……..

B2. Write the balanced equation of the reaction and the equations of the oxidation and reduction half-reactions

(1.50 points)

Calculation:

Balanced reaction: ……...……...

Oxidation: ……...

Reduction: ……...

B3. What mass of water ($\rho = 1\frac{g}{cm^3}$) is used to dilute the 10mL of solution S1 to obtain the required solution S2.

(1.00 points)

Calculation:

Mass of water =

B4. If the reaction has a 85% yield, what volume of solution S2 is used to obtain the desired amount of metal D.

(0.70 points)

Calculation:

Volume of solution =

B5. For the experiment described, 100mL of solution S3 containing substance C were stoichiometrically necessary. Find the pH of solution S3.

(0.70 points)

Calculation:

pH =

Extra space for problem 2:

Problem 3. Mineral Water (5.50 points)

A. In the following text, choose the right word from each pair of bolded words:

(0.30 points)

Circle the correct word:

> The solution to be analyzed is a **supersaturated/saturated** solution, a metastable (unstable) state, in which the solute concentration exceeds the theoretical limit and any small disturbance may cause it to **crystalize/dissolve**. To get the solution to a state where this is no longer a problem, the solution is **heated/cooled** and all analysis is performed at this temperature.

B. Choose which technique could have been used for the determination of calcium:

(0.20 points)

Tick the right answer:

Acid-base titration (based on the acid-base properties of calcium hydroxide)	
Redox titration (based on transformations between oxidation states of calcium)	
Complexonometric titration (based on the formation of a calcium complex)	
Argentometry (based on the formation of a silver-calcium precipitate)	

C. Calculate the total molar concentration of phosphorus in the solution.

(0.75 points)

Calculation:

Part C continuation:

Phosphorus concentration =

D. Using the acidity constants formulas, find the expressions of all phosphate system ions (dihydrogen phosphate, monohydrogen phosphate and neutral phosphate) in terms of acidity constants, the concentration of protons and the concentration of phosphoric acid.

(1.00 points)

Calculation:

$[H_2PO_4^-] =$

$[HPO_4^{2-}] =$

$[PO_4^{3-}] =$

E. Using results in parts C and D, find the values of the molar concentrations of phosphoric acid, dihydrogen phosphate, monohydrogen phosphate and neutral phosphate.

(1.50 points)

Calculation:

$[H_3PO_4]$ =

$[H_2PO_4^-]$ =

$[HPO_4^{2-}]$ =

$[PO_4^{3-}]$ =

F. Through calculations, determine which of the following compounds will precipitate when the solution is brought back to 25°C.

(1.75 points)

Calculation:

Part F continuation:

Tick the compounds that will precipitate:

$Ca(OH)_2$	
$Ca_3(PO_4)_2$	
$CaHPO_4$	

Extra space for problem 3:

Problem 4. Chemistry in a Parallel Universe (4.25 points)

Part A. Stable Elements (0.50 points)

Write the chemical symbol of the element which is the lightest element with a stable valance shell structure.

(0.50 points)

Chemical symbol - ……..

Part B. Properties of Aluminum (1.30 points)

B1. Using the given rules, draw the electron structure of aluminum.

(1.00 points)

Structure:

B2. Using the drawn electron structure, what element from our Universe does aluminum in the imaginary Universe resemble the most? Tick the right answer.

(0.30 points)

Neon	
Calcium	
Chlorine	
Sulfur	

Part C. More Chemical Properties (1.20 points)

C1. Give an example of an element which, in this imaginary Universe, would be a monovalent metal

(0.60 points)

Element = ……

C2. Give an example of an element, which, on this imaginary Universe, would be a divalent nonmetal

(0.60 points)

Element = ……

Part D. The Periodic Table (1.25 points)

D1. How many periods and how many groups does the periodic table of the imaginary Universe have?

Hint: In the imaginary periodic table, the f-block is added as an extension under the table just like in our Universe

(0.75 points)

Calculation:

Number of periods =

Number of groups =

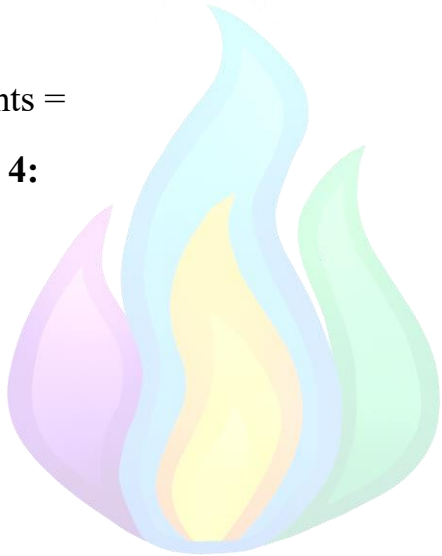
D2. How many elements are there in the s-block of the periodic table in the imaginary Universe?

(0.50 points)

Calculation:

Number of s-block elements =

Extra space for problem 4:



Problem 5. Electrochemical Cells (7.25 points)

Part A. Redox Reactions (0.75 points)

A1. Write the strongest reducing agent among those in the table.

(0.25 points)

Strongest reducing agent =

A2. Write the chemical reaction of fluorine and water.

(0.50 points)

Chemical reaction equation:

Part B. A Simple Electrochemical Cell (1.00 points)

B1. Write its symbol.

(0.50 points)

Symbol:

B2. Calculate the standard cell potential, E^0_{cell}

(0.50 points)

Calculation:

E^0_{cell} =

Part C. More Analysis of a Lead Battery (3.60 points)

C1. Calculate the potential of reaction (2).

(0.65 points)

Calculation:

E_2^0 =

C2. After some time of discharge, the concentration of H^+ ions near the Pb electrode decreases from 1.0 M to 0.80 M. Assuming the rate law for the cell reaction is:

rate $= k \times [H^+]^n$ with $k = 2.5 \times 10^{-3}$ (SI unit)

calculate:

(a) The rate of reaction at the beginning (when $[H^+]$ = 1.0 M)

(0.40 points)

Calculation:

Rate =

(b) The order n of the reaction, if it's known that the rate at 0.80 M is 64% of the initial rate.

(1.00 points)

Calculation:

n =

(c) The rate of reaction when $[H^+] = 0.80$ M

(0.20 points)

Calculation:

Rate =

C3. Based on your result from C2. estimate how long it will take for $[H^+]$ to fall from 1.0 M to 0.50 M. Assume no reverse reaction occurs and the rate law remains valid.

(0.60 points)

Calculation:

Time =

C4. Calculate the overall enthalpy change ΔH^0_{cell}

(0.75 points)

Calculation:

ΔH^0_{cell} =

Part D. Mass Changes in the Battery (1.90 points)

D1. Using the stoichiometry of the reaction, find the mass of lead that was oxidized

(0.40 points)

Calculation:

Mass of lead =

D2. Calculate by how much the total mass (mg) of the solid phase increases

(0.75 points)

Calculation:

Mass increase =

D3. If the actual measured increase of the total mass of the solid phase is 42mg, find the mass of lead sulfate that dissolved in water

(0.25 points)

Calculation:

Mass of lead sulfate dissolved =

D4. If the reaction is performed in a 1L aqueous solution, find the solubility (mg/L) of lead sulphate

(0.30 points)

Calculation:

Solubility =

Extra space for problem 5: