



GEOCHEMISTRY

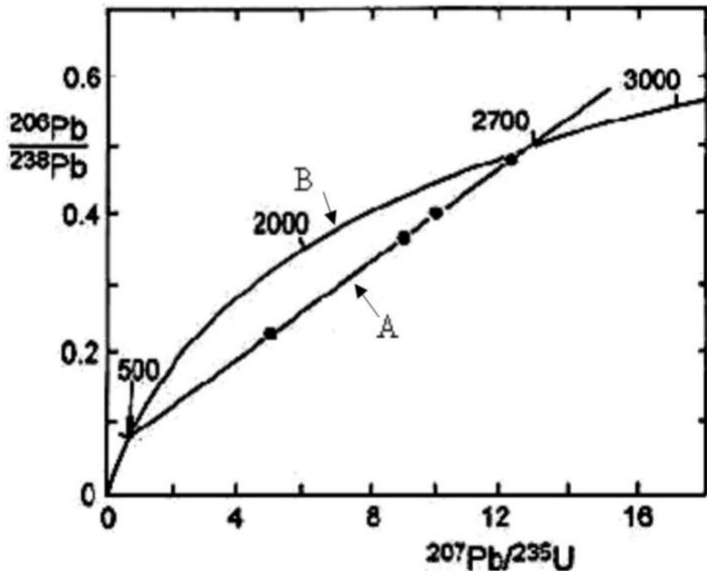
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TEST BANK

FINAL EXAM

SHAAS N HAMDAN

The following questions are related to diagram



1. What is the name of the diagram ?!
2. What is the name of the curve B ?!
3. What is the name of the line A ?!
4. The points on the diagram represent isotopic analysis of three different zircon's fractions from same rock. Give the interpretations of this data

1. Concordia diagram
2. Concordia curve
3. Discordia line

4. خلال حدوث geological events مثل metamorphism, change in T, & uplift يحدث diffusion للرصاص (اي يقل العمر المفترض وهو ما يسمى lead loss of time) والعينات الاصغر تفقد رصاص اكثر لذا كلما قل حجم العينة تباعد اكثر عن ال Concordia ويوجد نقطتي تقاطع بين ال Concordia و discordia وهما:

من الاعلى (2700Ma): العمر الاصلي للعينات (الصخر)
من الاسفل (500Ma): عمر ال event الذي سبب ال diffusion

What is the meaning of $\delta O_{18} = -20$

The sample (O18) is depleted in the heavy isotopes relative to the oceanic water

For the reaction $Cu^+ \rightleftharpoons Cu^{2+} + e$, Which of the two ions would be dominant in a stream whose measured potential (Eh) is +0.52 volt. Which is more oxidizing the stream water or the copper half-reaction? (G_f° kcal/mol for $Cu^+ = 11.95$, $Cu^{2+} = 15.65$)

$$Eh = \frac{\Delta G_R^\circ}{n \times 23.06} + \left(\frac{0.0592}{n} \right) \log \frac{[Cu^{2+}]}{[Cu^+]} = +0.52$$

$$0.52 - \frac{15.65 - 11.95}{1 \times 23.06} = \left(\frac{0.0592}{1} \right) \log \frac{[Cu^{2+}]}{[Cu^+]}$$

$$\log \frac{[Cu^{2+}]}{[Cu^+]} = 6.07 \rightarrow \frac{[Cu^{2+}]}{[Cu^+]} = 10^{6.073}$$

Cu^{2+} are dominant

Copper half-reaction is more oxidized than water because has less potential than water (stronger reducing agent)

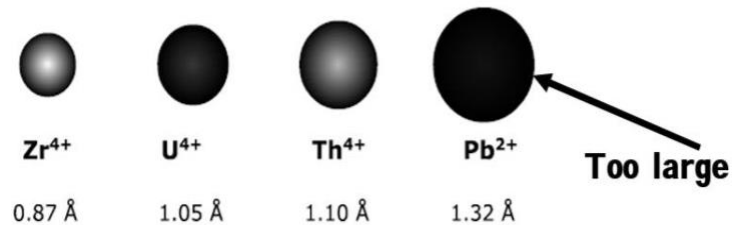
Explanation of Incongruent & congruent weathering

Congruent (compound is spelt completely into ions e.g. Calcite dissolution), &

Incongruent (compound is spelt into another compounds, ions, & molecules e.g. Al-silicates) & this behavior controlled by **chemical bonds** between parts of that compound (& may be controlled also by pH, Eh, & T of environments)

Scientific explanation: zircon has been considered as a best mineral to apply U-Pb method for age determination

Because U^{4+} & Th^{4+} are rapidly substitute for Zr^{4+} because have the same radius (more or less) & charges, but led are too large & have less charge



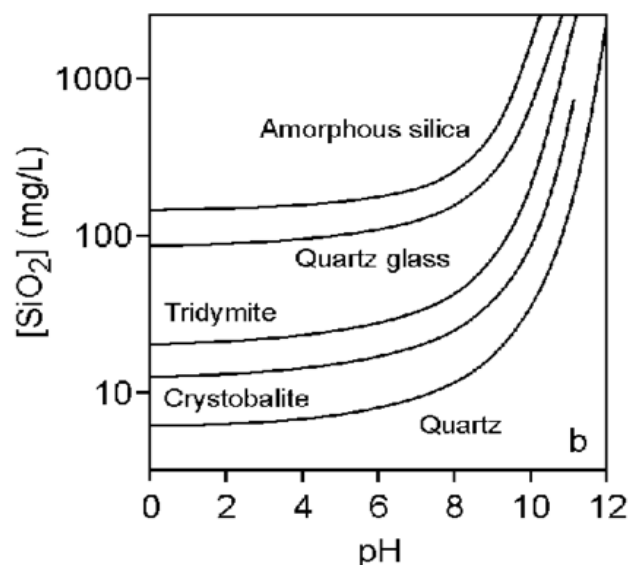
Scientific explanation: SMOW

The isotopic composition of O & H are measured by mass spectrometry & expressed relative to **SMOW**, The differences in isotopic ratios (**Delta Notation δ**) can be used to indicates if the sample are enriched in heavy elements (+ve δ) or depleted (-ve δ) relative to the seawater

(When water evaporates at equilibrium under constant P, isotopic composition of the vapor differs from that of the remaining water due to isotope fractionation during the evaporation)

Q5) a) What type of relation is shown in the diagram?

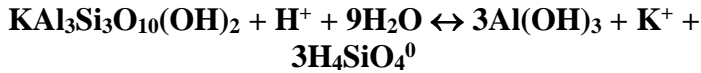
b) What type of information can you get from diagram?



- a) Geochemical divides, or pH controlling solubility diagram of silica group & amorphous silica
- b) Quartz has lower solubility than amorphous silica (solubility of quartz increases with pH) In acidic environment (pH<7) the solubility of amorphous silica is very low (precipitated), & increase rapidly in basic environment (≥8pH)

لا أفهم ما المقصود بكلمة type لذا الحل يمكن ان يكون غير صحيح

muscovite-gibbsite incongruent dissolution reaction



a) Use the data given to show which mineral is more stable in equilibrium with ground water with $[H_4SiO_4] = 10^{-4}$, $[K^+] = 10^{-3}$, pH = 7, T = 25 °C?

b) calculate the equilibrium constant of this reaction at STP?

ΔfG° in $kJ\ mol^{-1}$: $Al(OH)_3 = -1154.9$; $K^+ = -282.5$
 $H^+ = 0$, $H_4SiO_4 = -1307.8$, $KAl_3Si_3O_{10}(OH)_2 = -5608.4$, $H_2O = -237.1$

note: 1 kcal= 4.184 kJ

Ion	ΔfG° [kJ/mol]	ΔfG° [kcal/mol]	n	n ΔfG [Kcal]
$Al(OH)_3$	-1154.9	-276.03	3	-828.09
K^+	-282.5	-67.519	1	-67.519
H^+	0	0	1	0
H_4SiO_4	-1307.8	-312.572	3	-937.716
$KAl_3Si_3O_{10}(OH)_2$	-5608.4	-1340.44	1	+1340.44
H_2O	-237.1	-56.668	9	+510.012

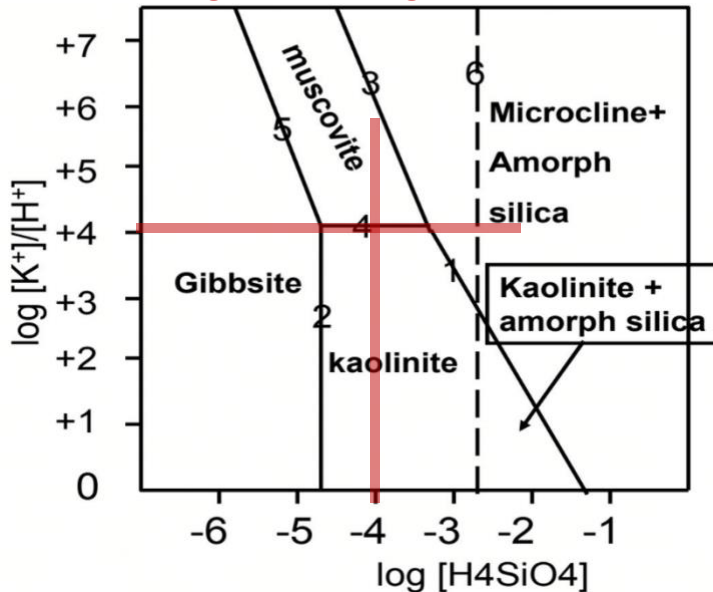
$$\Delta G^\circ = +17.127\text{kcal}$$

$$K = 10^{\frac{-\Delta G^\circ}{4.184}} = 10^{-(12.54)} = \frac{[H_4SiO_4]^3 [K^+]}{[H^+]}$$

$$\log \frac{[K^+]}{[H^+]} = -12.54 - 3 \log [H_4SiO_4]$$

$$\log \frac{[K^+]}{[H^+]} = \log 10^4 = 4$$

$$\log [H_4SiO_4] = \log 10^{-4} = -4$$



Muscovite are more stable than gibbsite
 Q7) Derive the Eh-pH equation for the dissolution of cuprite Cu_2O into Cu^{2+} , G°_f kcal/mol: $Cu_2O = -35.1$, $Cu^{2+} = 15.65$



$$\Delta G^\circ = -56.668 + 2 \times 15.65 + 35.1 = 9.732$$

$$E^\circ = \frac{9.732}{2 \times 23.06} = 0.211V$$

$$E = E^\circ + \left(\frac{0.05961}{n} \right) 2 \log \frac{[Cu^{2+}]}{[H^+]}$$

$$Eh = 0.211 + \left(\frac{0.05961}{2} \right) 2 \log \frac{[Cu^{2+}]}{[H^+]}$$

$$Eh = 0.211 + 0.05961 \log [Cu^{2+}] - 0.05961 \log [H^+]$$

$$Eh = 0.211 + 0.05961 \log [Cu^{2+}] + 0.05961 pH$$

$$Y = Eh$$

$$m = +0.05961$$

$$X = pH$$

$$b = (0.211 + 0.05961 \log [Cu^{2+}])$$

MIDTERM

SHAAS N HAMDAN

1. State three (primary) observations that led to explain the formation of our Solar system?(3)

A. All planets revolved in the same direction, & rotated in same direction (except of Venus) Because all have the same origin (Nebula rotating in the same sense of the galaxy)

B. All planets are on the same level relative to the sun (nebula acted upon by gravitational force, magnetic force, & electrical force which led to contraction of the rotating disk)

C. Planets closer to the sun are terrestrial planets & further from the sun are Jovian planets لان الرياح الشمسية قادرة على طرد الغازات الخفيفة من الكواكب القريبة منها مثل الهيدروجين والهيليوم ولان الشمس ايضا مصدر الحرارة تتجمد هذه الغازات عند الكواكب البعيدة

2. How can you explain the low abundance of heavy elements beyond iron?

Solu. These elements are produced during supernova stage (by neutron capture) & this stage is happening in a very short of time (so these elements can only formed in a short time), but the other elements such as Fe & lighter then Fe formed during red giant stage (over billions of years)

3. Explain in details why olivine is less resistant to weathering than the other silicates?(3)

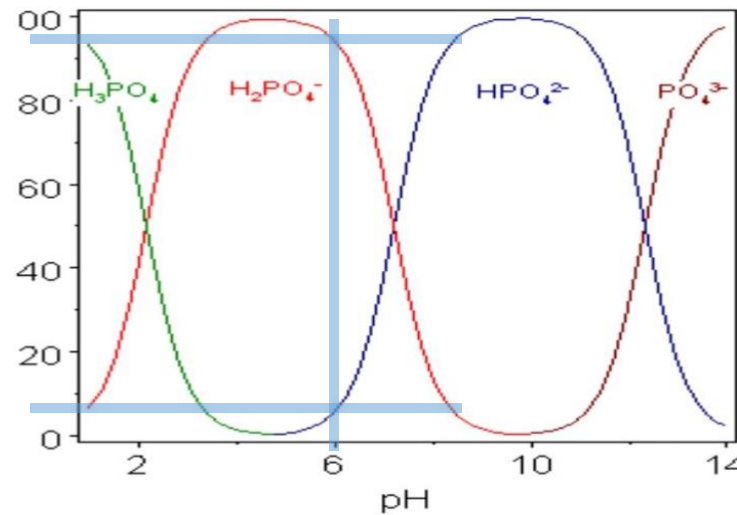
Chemically: olivine has highest ionic character (stronger ionic bond) than the other silicates & solubility of a compound increases with increasing ionic character, so olivine are less resistant to the weathering

Physically: Olivine are stable in a very high T-P conditions (in the mantle) & less resistant to the conditions at the earth's surface (i.e. Weathering conditions)

4. Why fairly high T-P inside a star are required to drive the triple alpha process creating ^{12}C from He?

Solu. α -particles are +ve particle, & the +ve charge increases with increasing Z (from He to C), so the repulsion forces between +ve nuclei & +ve α -particles increase with increasing Z, so more T-P are needed to overcome this forces

5. Depending on the following diagram, Answer the following questions.



A. What relationship does the diagram represent?(1)

pH controlling concentrations, or dissociation as a function of pH (curves shows concentration at different pH)

B. The possible types of Phosphoric acid speciation in the Solution are H_3PO_4 , H_2PO_4^- , HPO_4^{2-} & PO_4^{3-} , The total concentration of Phosphoric ions in a solution is 2×10^{-2} . What are the dominant Phosphorus species at pH 6? Calculate the concentration of each Species

$$\text{H}_3\text{PO}_4 = \text{HPO}_4^{2-} = 0$$

$$\text{H}_2\text{PO}_4^- = 95\%$$

$$\text{HPO}_4^{2-} = 5\%$$

$$[\text{H}_2\text{PO}_4^-] + [\text{HPO}_4^{2-}] = 0.02$$

$$[\text{H}_2\text{PO}_4^-] = 0.02 \times 0.95 = 0.019$$

$$[\text{HPO}_4^{2-}] = 0.02 \times 0.05 = 0.001$$

Dominant species is H_2PO_4^-

6. what is the incompatible elements & what make them Incompatible? In what type of rocks would you find them?

- **Incompatible:** element that tend to stay in a liquid (melt or magma) during crystallization
- **What make them Incompatible:** they have a large size and/or charge, so don't fit into a common rock-forming minerals during crystallization & become concentrated in a melts & crystallized at end phase of the magma
- **are highly concentrated in felsic rocks** (e.g. granite & granodiorite) which form by end phase of magma

7. What is the pH of a 0.50M solution of acetic acid, CH₃COOH, K_a = 1.8x10⁻⁵?

CH₃COOH	→	CH₃COO⁻ (aq)	+	H⁺ (aq)
0.50M		0		0
0.5 - x		x		x

[H⁺] = 3 x 10⁻³
pH = 3 - log3 = 2.5

8. The different stable isotopes of Carbon have similar or Different radii? Explain your answer.

Solu. No because in isotopes of the same element, the number of p+ & e- is the same but the number of n are changes. So the electromagnetic attraction between the p+ & e- remains consistent (& this force controlling the volume of any atom), & the volume of neutron itself is negligible

9. Si, K, Mg, Ca, Fe, & S can Replaces Rb, Sr, Sc, Li, REE (La - Lu), & Ni? Justify your choices using Goldschmidt's rules

Ion (Major)	EN	R in Å	Ion (trace)	EN	R in Å
Ca ²⁺	1.08	0.8	Rb ⁺	0.8	1.57
Fe ³⁺	1.8	0.6-0.73	Sr ²⁺	1.0	1.28
Mg ²⁺	1.2	0.8	Sc ²⁺	1.3	0.83
K ⁺	0.8	1.46	Ni ²⁺	1.8	0.77
Si ⁴⁺	1.8	0.48	REE ³⁺	1.1-1.2	1.13-0.94
S ⁶⁺	2.5	0.30	Li ⁺	1.0	0.82

Ca²⁺ vs Rb⁺ 1st rule: ΔR = 49.0% (>15%) ✗ → cannot occur
Ca²⁺ vs Sr²⁺ 1st rule: ΔR = 37.5% (>15%) ✗ → cannot occur
Ca²⁺ vs Sc²⁺ 1st rule: ΔR = 3.6% (<15%) ✓ 2nd rule: charge differ by 0 (≤1) ✓ 3rd rule: IP _{Ca} = 2.5 & IP _{Sc} = 2.41 → IP _{Ca} > IP _{Sc} ✗ Cannot occurs because Ca form stronger bound with anions
Ca²⁺ vs REE³⁺ 1st rule: ΔR = 14.89 - 29.2% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Ca} = 2.5 & IP _{REE} = 2.66 - 3.19 → IP _{Ca} < IP _{REE} ✓ 4th rule: ΔEN = 0.02 - 0.12 ✓ Occur, limited in coupled substitution to maintain neutrality
Ca²⁺ vs Ni²⁺ 1st rule: ΔR = 3.75% (<15%) ✓ 2nd rule: charge differ by 0 (≤1) ✓ 3rd rule: IP _{Ca} = 2.5 & IP _{Ni} = 2.597 → IP _{Ca} < IP _{Ni} ✓ 4th rule: ΔEN = 1.8 - 1.08 = 0.72 ✗ → may be occurs, but It probably doesn't
Ca²⁺ vs Li⁺ 1st rule: ΔR = 2.44% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Ca} = 2.5 & IP _{Li} = 1.22 → IP _{Ca} > IP _{Li} ✗ Substitution cannot occurs because Ca form stronger chemical bound with anions than Li

Fe³⁺ vs Li⁺ 2nd rule: charge differ by 2 (>1) ✗ → cannot occur
Fe³⁺ vs Sc²⁺ 1st rule: ΔR = 27.71 - 12.05% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Fe} = 5.0 - 4.11 & IP _{Sc} = 2.41 → IP _{Fe} > IP _{Sc} ✗
Fe³⁺ vs REE³⁺ 1st rule: ΔR = 22.34 - 46.90% (>15%) ✗
Fe³⁺ vs Sr²⁺ 1st rule: ΔR = 53.13-42.97% (>15%) ✗ → cannot occur
Fe³⁺ vs Ni²⁺ 1st rule: ΔR = 22.1 - 5.19% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Fe} = 5.0 - 4.11 & IP _{Ni} = 2.597 → IP _{Fe} > IP _{Ni} ✗
Fe³⁺ vs Rb⁺ 2nd rule: charge differ by 2 (>1) ✗ → cannot occur
Mg²⁺ vs Rb⁺ 1st rule: ΔR = 49.0% (>15%) ✗ → cannot occur
Mg²⁺ vs Sc²⁺ 1st rule: ΔR = 3.6% (<15%) ✓ 2nd rule: charge differ by 0 (≤1) ✓ 3rd rule: IP _{Mg} = 2.5 & IP _{Sc} = 2.41 → IP _{Mg} > IP _{Sc} ✗ Cannot occurs because Ca form stronger bound with anions (but can be occur is certain environment)
Mg²⁺ vs REE³⁺ 1st rule: ΔR = 14.89 - 29.2% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Mg} = 2.5 & IP _{REE} = 2.66 - 3.19 → IP _{Mg} < IP _{Sc} ✓ 4th rule: ΔEN = 0.1 - 0.0 ✓ Occur, limited in coupled substitution to maintain neutrality
Mg²⁺ vs Sr²⁺ 1st rule: ΔR = 37.5% (>15%) ✗ → cannot occur
Ca²⁺ vs Ni²⁺ 1st rule: ΔR = 3.75% (<15%) ✓ 2nd rule: charge differ by 0 (≤1) ✓ 3rd rule: IP _{Mg} = 2.5 & IP _{Ni} = 2.597 → IP _{Mg} < IP _{Sc} ✓ 4th rule: ΔEN = 1.8 - 1.08 = 0.6 ✓ → can be occurs
Mg²⁺ vs Li⁺ 1st rule: ΔR = 2.44% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _{Ca} = 2.5 & IP _{Li} = 1.22 → IP _{Ca} > IP _{Sc} ✗ Substitution cannot occurs because Ca form stronger chemical bound with anions than Li
K⁺ vs Rb⁺ 1st rule: ΔR = 7.01% (<15%) ✓ 2nd rule: charge differ by 0 (≤1) ✓ 3rd rule: IP _K = 0.685 & IP _{Rb} = 0.637 → IP _K > IP _{Rb} ✗ substitution cannot occur because K form stronger bound with anions than Rb (but the difference is not large, so can be occur in certain environment)
K⁺ vs Sc²⁺ 1st rule: ΔR = 11.1% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _K = 0.685 & IP _{Sc} = 2.41 → IP _{Mg} < IP _{Sc} ✓ 4th rule: ΔEN = 0.5 ✓ Can be occur
K⁺ vs Sr²⁺ 1st rule: ΔR = 12.33% (<15%) ✓ 2nd rule: charge differ by 1 (≤1) ✓ 3rd rule: IP _K = 0.685 & IP _{Sr} = 1.563 → IP _K < IP _{Rb} ✓ 4th rule: ΔEN = 0.2 ✓ Occur, but limited in coupled substitution to maintain neutrality
K⁺ vs Ni²⁺ 1st rule: ΔR = 47.3% (>15%) ✗
K⁺ vs REE³⁺ 1st rule: ΔR = 22.60 - 35.62% (>15%) ✗
K⁺ vs Li⁺ 1st rule: ΔR = 43.84% (>15%) ✗
Si⁴⁺ vs (Rb⁺, Sr²⁺, Sc²⁺, Ni²⁺, & Li⁺) 2nd rule: charge differ by > 1 ✗ → cannot occur
Si⁴⁺ vs REE³⁺ 1st rule: ΔR = 48.94 - 57.52% (>15%) ✗ → cannot occur
S⁶⁺ vs (Rb⁺, Sr²⁺, Sc²⁺, Ni²⁺, REE³⁺, & Li⁺) 2nd rule: charge differ by > 1 ✗ → cannot occur