BIRKBECK COLLEGE
(University of London)

BSc EXAMINATION

SCHOOL OF SCIENCE

DEPARTMENT OF EARTH AND PLANETARY SCIENCES

INTRODUCTION TO GEOCHEMISTRY

EASC038H4

15 CREDITS

Thursday 19 May 2016

14:30 – 16:30

INSTRUCTIONS

Answer THREE questions. [Candidates are advised to spend FORTY minutes on each question. Use diagrams and chemical reactions to support written answers wherever possible]

ALL QUESTIONS CARRY EQUAL MARKS

[Candidates will be provided with a Periodic Table of the Elements and an Equation bank]

1. Describe the structure of the atom, including in your answer information on the nucleus, protons, neutrons, electrons, quantum numbers, shells and subshells.

2. Explain how the carbon-carbon bonding differs between graphite and diamond. Use these differences in bonding to explain why (i) diamond is hard and graphite is soft and (ii) diamond is an insulator and graphite is a conductor.

3. Write down the Condensed Phase Rule and explain what is meant by the terms ‘component’, ‘phase’ and ‘number of degrees of freedom’. Draw a sketch of the fayalite-forsterite T-X diagram and use it to explain how a liquid with an initial composition of 60% forsterite and 40% fayalite changes as it cools from 1900°C to 1200°C.

4. Describe how oxygen and hydrogen isotope fractionation occurs in the hydrosphere. Explain, using diagrams, how oxygen and hydrogen isotopes vary with latitude.

5. (a) Using examples and equations, define the terms:

- solution;
- acid;
- pH;
- ionic strength.

(b) Sketch an Eh-pH diagram for natural environments and use it to show the lower and upper limits of water stability and the stability fields for the solid and dissolved species of iron.

6. Describe the chemical weathering processes of dissolution, hydrolysis, oxidation and reduction.

Equation Bank

$\Delta H = H_{products} - H_{reactants}$

$G = H – TS$

$\Delta G = \Delta H – T\Delta S$

$k = A\ e^{-Ea/RT}$

$\varphi + F = C + 2$

$\varphi + F = C + 1$

$J_i = -D_i\ dc_i/dx$

$N = N_0 e^{-\lambda t}$

$\delta P/\delta T = \Delta S/\Delta V$

$\delta c_{product} / \delta T = \delta c_{reactant} / \delta T$

$J_i = -D_i\ \delta c_i / \delta x$

$K = [C]^c\ [D]^d\ [E]^e\ /\ [A]^a\ [B]^b$

$I = ½\ \Sigma\ m_i\ z_i^2$

$D = P\ (e^{\lambda t} - 1) + D_0$

$t_{½} = \ln 2 / \lambda$

$^{87}Sr = {}^{87}Rb * (e^{\lambda t} - 1) + {}^{87}Sr_0$

$^{87}Sr/^{86}Sr = {}^{87}Rb/^{86}Sr * \lambda t + {}^{87}Sr/^{86}Sr_0$

$\delta y/\delta x = \lambda t$

$\delta_{sample} = (R_{sample} – R_{standard} / R_{sample})\ *1000$

WebElements: the periodic table on the world-wide web

http://www.webelements.com/

Key:

element name atomic number **symbol** atomic weight (mean relative mass)

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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												aluminium 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]	darmstadtium 110 **Ds** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

*lanthanoids	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
**actinoids	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** [258]	nobelium 102 **No** [259]

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org/). Names have yet to be proposed for the most recently discovered elements 111–112 and 114 so those used here are IUPAC's temporary systematic names. In the USA and some other countries, the spellings **aluminum** and **cesium** are normal while in the UK and elsewhere the common spelling is **sulphur**.
Group labels: the numeric system (1–18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): Apart from the heaviest elements, these are the IUPAC 2001 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest lived isotope.