

Name:

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Q1 (20)	Q2 (20)	Q3 (20)	Q4 (20)	Q5 (20)	TOTAL (100)

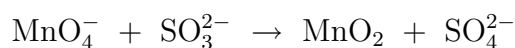
Masses of fundamental particles

Particle	Mass (kg)	Mass (atomic u)
electron	$9.1094 \times 10^{-31}$	0.00054858
proton	$1.6726 \times 10^{-27}$	1.0073
neutron	$1.6749 \times 10^{-27}$	1.0087

1. (a) (1 point each) Put T for true and F for false after each statement.
- I. The number of C atoms in exactly 12 g of C element is equal to Avogadro's number. ( )
  - II.  $\gamma$ -rays are not deflected in an electrostatic field. ( )
  - III. Rutherford has scattered  $\alpha$  particles to demonstrate the existence of nuclei. ( )
  - IV. The oxidation state of carbon in  $\text{H}_2\text{CO}$  is +4. ( )
  - V. The name of  $\text{Cu}_2\text{O}$  is copper(II) oxide. ( )
  - VI.  $1 \frac{\text{g}}{\text{mL}} > 1 \frac{\text{kg}}{\text{m}^3}$ . ( )
  - VII. According to Kepler, sun is located at one of the foci of earth's orbit. ( )
  - VIII. The surface area of a cube of side  $a = 1.1 \text{ m}$  is  $S = 6 \times (1.1 \text{ m})^2 = 7.26 \text{ m}^2$ . ( )
  - IX.  $\text{N}_2\text{H}_4$  is the empirical formula of hydrazine. ( )
  - X. Percent yield gives the error done in the experimental reaction. ( )

(b) (5 points) Explain why application of a velocity filter to positively charged ions is necessary in the experiments of mass spectroscopy.

(c) (5 points) Balance this redox reaction in basic solution.



**2.** Binding energy (BE) of a nucleus is calculated through  $BE := \Delta mc^2$  where  $\Delta m$  is the “lost mass” in the formation of the nucleus and  $c = 299792458$  m/s is the speed of light. The average binding energy (ABE) is the ratio of the binding energy to the mass number  $A$ . Therefore  $ABE := \frac{BE}{A}$ . It is a measure of the energy stored per nucleon. (Nucleon is the generic name of protons and neutrons.)

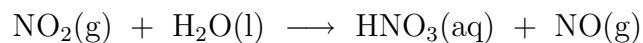
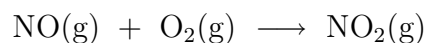
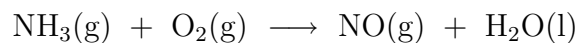
The following table summarizes the situation of four isotopes of iron.

isotope	isotopic mass (u)	percent natural abundance (%)
${}_{26}^{54}\text{Fe}$	53.9396105	5.845
${}_{26}^{56}\text{Fe}$	55.9349375	91.754
${}_{26}^{57}\text{Fe}$	56.9353940	2.119
${}_{26}^{58}\text{Fe}$	57.9332756	0.282

**(a)** (15 points) Evaluate the ABE (in Joules) for each of these isotopes. Which one has the most energy stored per nucleon? (Remember that  $1 \text{ J} := \text{kg} \frac{\text{m}^2}{\text{s}^2}$  and  $1 \text{ u} = 1.660538782 \times 10^{-27} \text{ kg}$ .)

**(b)** (5 points) Based on the information given in this question, what is the relative atomic mass of iron as given in the periodic table? (Please pay special attention to significant figures.)

**3.** Nitric acid can be manufactured from ammonia by using the three consecutive reactions shown below.



**(a)** (10 points) Balance these reactions and indicate the oxidation state of N in each case?

In parts (b) and (c) assume that each reaction in the process occurs with 70.0% yield. For 1.00 mol of initial ammonia

**(b)** (5 points) How many moles of nitric acid is produced?

**(c)** (5 points) What is the *net* amount of water that is consumed (or produced) in the overall process?

4. *Hydrates* are ionic compounds that possess water molecules incorporated into their solid structures. A hydrate of copper(II) sulfate,  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ , can be prepared by the reaction of metallic copper with sulfuric acid and nitric acid. From the reaction of 0.2000 g of metallic copper with a mixture of nitric acid and sulfuric acid in aqueous solution, one obtains 0.7858 g of the hydrate. (a) (8 points) What is  $x$  in the formula of the hydrate? (The relative atomic masses are Cu: 63.546, S: 32.065, O: 15.9994, H: 1.00794, and N: 14.0067 g/mol.)

(b) (12 points) Write and balance the reaction that takes place during the synthesis of this hydrate by exploiting the information that nitric acid is reduced to nitrogen dioxide.

**5.** *Hyrides* are ionic compounds in which hydrogen is in the oxidation state of  $-1$ . Hydride anion reacts vigorously with water to produce hydrogen gas.

**(a)** (8 points) Write the half *and* net reactions that take place during the comproportionation reaction of hydride and water in basic solution.

**(b)** (12 points) A 7.6640 g mixture of sodium hydride and magnesium hydride are reacted with water to produce 1.00794 g of hydrogen gas. What is the percentage of sodium hydride in the mixture? (The relative atomic masses are Na: 22.9898, Mg: 24.3050, H: 1.00794, and O: 15.9994 g/mol.)