NAME:

75 MINUTES; HAND IN YOUR 1 SHEET OF NOTES WITH THE EXAM; ASK FOR EXTRA PAPER IF NEEDED. MAKE (AND STATE) ANY REASONABLE ASSUMPTIONS NECESSARY TO GET AN ANSWER IN ADDITION TO THOSE GIVEN. CHECKING WHETHER THE ANSWER MAKES SENSE IS NOT REQUIRED HERE BUT MAY HELP YOU EARN PARTIAL CREDIT IF YOU WENT WRONG SOMEWHERE.

PROBLEM 1 (40 pts):

Estimate the added cancer risk for a 50-kg individual who is exposed to 0.3 mg m^{-3} formaldehyde (CH_2O) in her workplace's air, and determine whether the risk is acceptable. Assume that exposure occurs 8 hours per day, 5 days per week, 50 weeks per year, for 10 years. The potency factor for inhaled formaldehyde is thought to be 0.2 kg day mg^{-1}.

PROBLEM 2 (25 pts):
How many liters of pure oxygen (O_2) at 30°C and a pressure of 1 atm are required to burn 1 kg methane (CH_4)? The reaction stoichiometry is $CH_4(g)+2O_2(g)\rightarrow 2H_2O(g)+CO_2(g)$.

PROBLEM 3 (25 pts):
A river channel has a half-circle cross-section with diameter 2 m. The velocity profile in the river channel is radial and given as $v(r) = v_0(1 - r/R)$, where $v_0 = 4$ m s^{-1} and R is the channel radius.

(a) How many kg of water are in a 100-m length of the river?

(b) What is the volume flow rate of the river?

PROBLEM 4 (10 pts):
In what category or type is each of the following chemical reactions?

(a) $CaCO_3(s) \leftrightharpoons Ca^{+2} + CO_3^{-2}$

(b) $SO_2(g) \leftrightharpoons SO_2(aq)$

(c) $HI(aq) \leftrightharpoons H^{+} + I^{-}$

(d) $C_6H_{14}(aq) \leftrightharpoons C_6H_{14}(ads)$

What do these reaction types all have in common?

GIVEN INFORMATION

1 m^3 = 1000 L, 1 mg = 10^{-3} g, 1 µg = 10^{-6} g

T(degK) = T(degC) + 273.15, 1 atm = 101325 Pa

$$\mathrm{MW}_i = \frac{\text{mass i}}{\text{mols i}} = \sum_{k=1,K} n_k \mathrm{AW}_k, \quad \mathrm{FW} = \sum_{k=1,K} y_i \mathrm{MW}_i$$

PV=nRT   where R=0.08206 L atm mol^{-1} K^{-1}

$$\rho_{air} = \frac{\text{mass air}}{\text{volume air}} = \frac{n_{air} \times MW_{air}}{V_{air}} = \frac{n_{air}}{V_{air}} \times MW_{air} = \frac{P}{RT} \times MW_{air}$$

$$M_i = \frac{\text{mols i}}{\text{L m}} = \frac{\text{mass}_i / \mathrm{MW}_i}{V_w} = \frac{m_i}{\mathrm{MW}_i}$$

$$\mathrm{pH} = -\log(M_{H^+}),\ \mathrm{pOH} = -\log(M_{OH^+}),\ \mathrm{pH} + \mathrm{pOH} = 14 \text{ at } 25°\mathrm{C}$$

$$y_i = \frac{\text{mols i}}{\text{mols t}} \approx \frac{\text{mass}_i / MW_i}{\rho_m \times V_m / MW_m} \quad \text{and} \quad \sum_{i=1,I} y_i = 1$$

$$\mathrm{P}_i = y_i \mathrm{P} \quad \text{and} \quad \sum_{i=1,I} P_i = P$$

AW of elements in g/mol: 1 for H, 12 for C, 14 for N, 16 for O, 31 for P, 32 for S

Density of pure water at 1 atm and 4°C = 1000 kg/m^3

$$\text{Lifetime risk of death} = \text{Chronic Daily Intake} \times \text{Potency Factor}$$

$$\text{Chronic Daily Intake} = \frac{\text{Exposure concentration} \times \text{Intake rate} \times \text{Exposure duration}}{\text{Body weight} \times \text{Lifetime}}$$

$$0.5 \times C(0) = C(0) e^{-kt_{1/2}} \text{ and } k = -\ln(0.5) / t_{1/2}$$

$$\text{Exposure concentration} = C(0) \times e^{-kt} \times \text{Bioconcentration factor}$$

$$\text{Lifetime hazard quotient} = \frac{\text{Chronic Daily Intake}}{\text{Reference Dose}}$$

$$\frac{d}{dt} \int_{cv} \rho \, d\forall = -\int_{cs} \rho \, V(A) \cdot n \, dA \quad \text{and} \quad \frac{d}{dt} \int_{cv} \rho \, d\forall = \frac{dm}{dt}$$

$$\int_{cs} \rho \, V(A) \cdot n \, dA = -\int_{cs,in} \rho \, V(A) \, dA + \int_{cs,out} \rho \, V(A) \, dA = \sum_{cs,in} \rho \, \bar{V} A - \sum_{cs,out} \rho \, \bar{V} A = \sum_{cs,in} \dot{m} - \sum_{cs,out} \dot{m}$$

Land use	Exposure pathway	Intake rate (amount/day)	Exposure frequency (day/year)	Exposure duration (year)
Residential	Ingestion of potable water	2 L	350	30
	Ingestion of homegrown produce	42 g (fruit) 80 g (veg.)	350	30
	Ingestion of locally caught fish	54 g	350	30
	Ingestion of soil or dust	200 mg	350	30
	Inhalation of air	20 m^3	350	30
Industrial or commercial	Ingestion of potable water	1 L	250	25
	Ingestion of soil or dust	50 mg	250	25
	Inhalation of air	20 m^3	250	25