2014 ChemE Jeopardy Clues/Responses

Preliminary Round

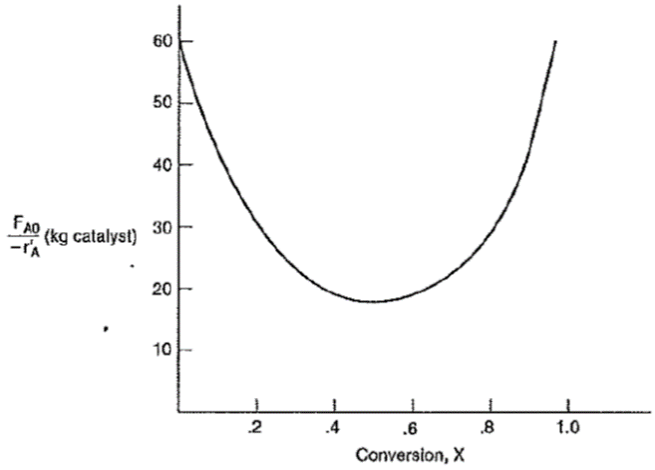
Single Jeopardy:

Chemical Reaction Engineering

100: The temperature dependence of a chemical reaction is commonly described through the use of this equation.

What is the Arrhenius equation?

200: The Optimal (i.e., smallest total reactor volume) order of 2 ideal reactors in series to achieve 80% conversion for the kinetics denoted here.



What is a CSTR followed by a PFR?

300: Enzyme kinetics described by the following equation:

$$-r_s = \frac{V_{max}(S)}{K_M + (S)}$$

What are Michaelis-Menten Kinetics?

400: This dimensionless number, given by τk for a first-order reaction, provides an estimate of the conversion in a CSTR.

What is the Damköhler number?

500: This modulus (as shown below) is useful in predicting reactor behavior when solid catalyst particles are used.

$$L\sqrt{\frac{k'''}{D_{eff}}}$$

What is the Thiele Modulus?

Math

100: This geometric entity, having both magnitude and direction, motivated a villain in the comedy film *Despicable Me*.

What is a vector?

200: Given the lengths of 2 sides of a triangle and the corresponding angle in between, this law will provide the length of the 3rd side.
What is the Law of Cosines?
300: In differential calculus, this famous rule uses derivatives to evaluate limits involving indeterminate forms.
What is L'Hôspital's rule?
400: In 1637, Descartes published *La Géométrie*, which contained the first written form of this famous equation used to find roots of a second-order polynomial.
What is quadratic formula?
500: This famous identity states that $e^{i\pi} + 1 = 0$.
What is Euler's Identity?

Unit Operations
100: This process equipment is used to transfer energy between process streams.
What is a heat exchanger?
200: This process involves vaporizing a portion of a liquid feed. The vapor contains a concentration of the more volatile component.
What is distillation?
300: In this process, components of a fluid phase are transferred to the surface of a solid phase.
What is adsorption?
400: A simplified version of this unit operation is making coffee from ground beans. A component is removed from a solid by a liquid solvent.
What is leaching?
500: This process equipment uses a drum to continuously separate solids from a slurry. The cake is continuously removed by a knife.
What is a rotary drum filter?

Thermodynamics
100: This chart contains the dry bulb temperature, the humidity ratio, the wet bulb temperature, relative humidity, saturation temperature, and the enthalpy of dry air.
What is psychrometric chart?
200: This is equal to H – TS
What is Gibbs Free Energy (G)?
300: This factor is used to account for deviations from ideal behavior in a liquid mixture of chemical substances.
What is an activity coefficient?
400: This law states that as the temperature approaches 0 K, the entropy of the system approaches a minimum value.
What is the third law of thermodynamics?
500: This is the most common engine cycle that does not use a spark.
What is a diesel engine?

Chemical Process Safety
100: This is defined as a chemical or physical condition that has the potential for causing damage to people, property or the environment.
What is a hazard?

200: This is defined as a rapid expansion of gases resulting in a rapidly moving pressure or shock wave.
What is an explosion?
300: This type of spring-loaded relief valve is used when high backpressures are present.
What is a balanced bellows?
400: The deflagration index for gases and dusts is calculated by multiplying $(dP/dt)_{max}$ by the volume (V) raised to this power.
What is 1/3?
500: This equipment, abbreviated ARSST, is commonly used to evaluate reactive hazards.
What is the Advanced Reactive System Screening Tool?

<u>Fictional Minerals</u>
100: This causes superman to lose his super powers.
What is kryptonite?
200: Used to control the power of the warp drive system of starships on *Star Trek*.
What are dilithium crystals?
300: Provided the means for Professor Brainard's car to fly in the 1961 movie *The Absent-Minded Professor*.
What is flubber?
400: Used to fuel Martian reactors in *The War of the Worlds*.
What is Heavy Elements?
500: This mysterious substance was accidently used by Professor Utonium when he created the *Powerpuff Girls*, thereby giving them superpowers.
What is Chemical X? (or What is a can of Whoopass?)

Final Round

Single Jeopardy:

Process Design

100: This tax is levied on profits made from the sale of capital assets.
What is Capital Gains Tax?
200: This is added to the depreciation charge to obtain the cash flow.
What is the net profit?
300: This is the most common material of construction in the chemical process industry.
What is carbon steel?
400: Nonmanufacturing fixed-capital investment is also known as this.
What are indirect costs?
500: This is defined as the ratio of gross annual sales and fixed-capital investment.
What is the turnover ratio?

Chemistry

100: This is a rapid reaction of a fuel with oxygen.
What is a combustion reaction?
200: This principle states that if an external stress is applied to a system at equilibrium, then the system will adjust in such a way to partially offset this stress.
What is Le Chatelier's Principle?
300: This term describes an object that is not superimposable on its mirror image.
What is chiral?
400: The following reaction: $2Ca(s) + O_2 \rightarrow 2CaO(s)$ is an example of this type of electron transferring reaction.
What is an oxidation-reduction reaction?
500: This reaction converts a diene and an alkene into a six membered ring containing an alkene.

What is the Diels-Alder reaction?

Fluid Flow

100: This dimensionless number is defined as the ratio of inertial forces to viscous forces.
What is the Reynolds number?
200: This term is defined as the ratio of the dynamic fluid viscosity to the fluid density.
What is the kinematic viscosity?
300: This principle states that for an inviscid flow of a nonconducting fluid, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.
What is Bernoulli's Principle?
400: These additional restraints provide closure to differential equations describing a finite domain.
What are boundary conditions?

500: This simple constitutive model provides a linear relationship between the viscous shear tensor and the velocity gradient.
What is Newton's law of viscosity?

Process Control
100: This is the most commonly manipulated process variable (by control loops) in the Chemical Process Industry.
What is flow rate?
200: This type of control uses the sensor reading and the setpoint to set the value of the manipulated variable for a process.
What is feedback control?
300: The maximum positive and negative change in the signal to the final control element that does not produce a measurable change to the flow rate in question.
What is the valve deadband?
400: Too much of this type of control action will result in a closed-loop response that has a stair-step shape.
What is derivative control action?
500: The characteristic of a second-order process that determines the general shape of the dynamic response.
What is the damping factor?

Historical Firsts
100: He was the first person to break the sound barrier in an aircraft.
Who was Chuck Yeager?
200: She was the first woman to swim from Cuba to Florida without a shark cage.
Who was Diana Nyad?
300: She was the first American woman to fly in space.
Who was Sally Ride?
400: He was the first American to run a 4 minute mile.
Who was Jim Ryun?
500: This was the first movie to win an Oscar for best picture.
What was *Wings*?

Material and Energy Balances
100: DoF = #components - #phases + 2
What is the Gibbs Phase Rule?
200: This process stream is removed from a recycle to prevent an excessive buildup of inerts.
What is a purge stream?
300: This is a method of constructing new data points within the range of a discrete set of known data points.
What is interpolation?
400: For a complete reaction, this would be completely consumed.
What is the limiting reactant?
500: This law states that the enthalpy or heat change accompanying a chemical reaction is independent of the pathway between the initial and final states.
What is Hess's Law?

Final Round

Double Jeopardy:

Industrial Processes

200: The Haber process is used to produce this.
What is ammonia?
400: The lead chamber process is used to produce this.
What is sulfuric acid?
600: Nitric acid is most commonly produced using this process.
What is the Ostwald process?
800: The Hall-Heroult process is used to make this.
What is aluminum?
1000: The Dow process is used to make this.
What is bromine?

Physics

200: This vector quantity is the product of a mass and an acceleration.
What is a force?
400: This force is proportional to the normal force, but independent of the magnitude of the area of contact.
What is friction?
600: This mass property of a rigid body determines the torque needed for a desired angular acceleration.
What is the moment of inertia?
800: This law states that the force needed to extend or compress a spring by some distance is proportional to that distance.
What is Hooke's Law?
1000: In polymer physics, this parameter is used to describe the dimension of a polymer chain and is defined as being proportional to the root mean square distance between the monomers.
What is the radius of gyration?

Chemical Elements

200: This is the most prevalent element (by weight) in the human body.
What is oxygen?
400: This is the second-most abundant element in the universe, though it is much less common on Earth.
What is helium?
600: The Statue of Liberty contains 125 tons of steel and 31 tons of this element.
What is copper?
800: This is the best electric conductor of the elements.
What is silver?
1000: This is the only element that shows antiferromagnetic ordering in its solid state at and below room temperature.
What is chromium?

Biochemical Engineering

200: This is the most commonly used bacterium in industrial processes (full name please).

What is *Escherichia coli*?

400: This plot of 1/S vs. 1/v is commonly used to determine v_{max} and K_M for enzymes that follow Michaelis-Menton kinetics.

What is a Lineweaver-Burk plot?

600: The bacterial growth model given by

$$\mu = \frac{\mu_m S}{K_s + S}$$

What is the Monod equation?

800: This byproduct of the sugar processing industry is commonly used as an economical carbon source for bacterial fermentations.

What is molasses?

1000: In a chemostat run at steady state, the specific growth rate (μ) is equal to this.

What is the dilution rate (D)?

Heat Transfer

200: This dimensionless number is effectively the ratio of the viscous diffusion rate to the thermal diffusion rate.

What is the Nusselt number?

400: This type of heat transfer results solely from fluid motion causes by density differences that result from temperature differences.

What is natural convection?

600: He first proposed the heat conduction equation in 1822.

Who was Joseph Fourier?

800: This dimensionless parameter is the ratio of the heat conduction rate to the rate of thermal energy storage.

What is the Fourier Modulus?

1000: This parameter, which is used in radiative heat transfer, is defined by

$$\frac{1}{A_1} \int_{A_1} \int_{A_2} \frac{\mathrm{Cos}(\theta_1)\,\mathrm{Cos}(\theta_2)\,dA_1\,dA_2}{\pi r^2}$$

What is the view factor?

Fires and Explosions

200: An explosion in which the reaction front moves at a speed greater than the speed of sound in the unreacted medium.

What is a detonation?

400: These are the 3 sides of the fire triangle.

What are fuel, oxidizer and ignition source?

600: These are the 5 sides of the dust explosion pentagon.
What are fuel, oxidizer, ignition source, suspension and confinement?
800: The type of explosion that occurred during the 1989 Phillips 66 accident in Pasadena, TX.

What was a vapor cloud explosion (VCE)?
1000: The type of explosion that occurred in the 1984 Mexico City accident.

What was a Boiling Liquid Expanding Vapor Explosion (BLEVE)?

Final Round

Final Jeopardy Category: Heat Transfer

This is the heat flux through a single-layer wall (in W/m^2) when the temperatures on the two sides of the wall are 10ºC and 110ºC. The wall is 10 cm thick and the thermal conductivity is 0.1 W/m-K. You must show your work!

What is 100 W/m^2?

$$\dot{q} = \frac{\dot{Q}}{A} = \frac{T_2 - T_1}{R * A} = \frac{T_2 - T_1}{\frac{L}{A} * \left[\frac{1}{k_1}\right] * A}$$

$$\dot{q} = \frac{110K - 10K}{0.1m\left[\frac{1}{0.1}\right]\frac{K * m}{W}} = 100\frac{W}{m^2}$$