Assigned problems for Lecture 6 are listed below. The questions occur in the following editions of "Physical Chemistry" by P.W. Atkins:

10th edition	9th edition	8th edition

Note: The letter "P" in front of a number indicates that the question is in the "Problem" category as opposed to the "Exercise" category in Atkins' books. Updates are highlighted in yellow.

Set 1

Question 6.01

n/a	2.1	2.1

These are problems from the 8th and 9th, but discontinued in the 10th Ed.

2.1, (8th, 9th Eds.) (a) Calculate the work needed for a 65 kg person to climb through 4.0 m on the surface of (a) the Earth and (b) the Moon ($g = 1.60$ m s^{-2}).

2.1, (8th, 9th Eds.) (b) Calculate the work needed for a bird of mass 120 g to fly to a height of 50 m from the surface of the Earth.

Question 6.02

2A.3	2.2	2.2

Slight variation in 10th edition questions - just the values are different, no change in how the exercise is solved.

2.2(a) A chemical reaction takes place in a container of cross-sectional area 100 cm^2. As a result of the reaction, a piston is pushed out through 10 cm against an external pressure of 1.0 atm. Calculate the work done by the system

2.2(b) A chemical reaction takes place in a container of cross-sectional area 50.0 cm^2. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121 kPa. Calculate the work done by the system.

2A.3(a) A chemical reaction takes place in a container of cross-sectional area 50 cm^2. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 1.0 atm. Calculate the work done by the system.

2A.3(b) A chemical reaction takes place in a container of cross-sectional area 75.0 cm^2. As a result of the reaction, a piston is pushed out through 25.0 cm against an external pressure of 150 kPa. Calculate the work done by the system.

Question 6.03

2A.5	2.4	2.4

2A.5(a) A sample consisting of 1.00 mol of perfect gas atoms, for which $C_{V,m} = \frac{3}{2}R$, initially at p_1 = 1.00 atm and T_1 = 300 K, is heated reversibly to 400 K at constant volume. Calculate the final pressure, ΔU, q, and w.

2A.5(b) A sample consisting of 2.00 mol of perfect gas molecules, for which $C_{V,m} = \frac{5}{2}R$, initially at p_1 = 111 kPa and T_1 = 277 K, is heated reversibly to 356 K at constant volume. Calculate the final pressure, ΔU, q, and w.

Question 6.04

2A.6	2.5	2.5

2A.6(a) A sample of 4.50 g of methane occupies 12.7 dm^3 at 310 K. (i) Calculate the work done when the gas expands isothermally against a constant external pressure of 200 Torr until its volume has increased by 3.3 dm^3. (ii) Calculate the work that would be done if the same expansion occurred reversibly.

2A.6(b) A sample of argon of mass 6.56 g occupies 18.5 dm^3 at 305 K. (i) Calculate the work done when the gas expands isothermally against a constant external pressure of 7.7 kPa until its volume has increased by 2.5 dm^3. (ii) Calculate the work that would be done if the same expansion occurred reversibly.

Question 6.05

n/a	n/a	n/a

These is a problem from the 7th edition **(Ex. 2.10a, 7th Ed.)** *that was discontinued from later editions.*

Ex. 2.10a, 7th Ed. In the isothermal reversible compression of 52.0 mmol of a perfect gas at 260 K, the volume of the gas is reduced to one-third of its original value. Calculate the w for this process.

Answer: **(Ex. 2.10a, 7th Ed.),** w = +123 J (use $w = -nRT \ln (V_f/V_i)$), see below for full solution.

Question 6.06

n/a	2.7	2.7

Yet another good problem which seems to be missing.

2.7 (8th, 9th Eds.) (a) A strip of magnesium of mass 15 g is placed in a beaker of dilute hydrochloric acid. Calculate the work done by the system as a result of the reaction. The atmospheric pressure is 1.0 atm and the temperature 25°C.

2.7 (8th, 9th Eds.) (b) A piece of zinc of mass 5.0 g is placed in a beaker of dilute hydrochloric acid. Calculate the work done by the system as a result of the reaction. The atmospheric pressure is 1.1 atm and the temperature 23°C.

Solution 6.01

n/a	2.1	2.1

E2.1(a) The physical definition of work is $dw = -F\,dz$ [2.5].

In a gravitational field the force is the weight of the object, which is $F = mg$.

If g is constant over the distance the mass moves, dw may be integrated to give the total work

$$w = -\int_{z_i}^{z_f} F\,dz = -\int_{z_i}^{z_f} mg\,dz = -mg(z_f - z_i) = -mgh, \quad \text{where} \quad h = (z_f - z_i)$$

On earth: $w = -(65\text{ kg}) \times (9.81\text{ m s}^{-2}) \times (4.0\text{ m}) = -2.6 \times 10^3\text{ J} = \boxed{2.6 \times 10^3\text{ J needed}}$

On the moon: $w = -(65\text{ kg}) \times (1.60\text{ m s}^{-2}) \times (4.0\text{ m}) = -4.2 \times 10^2\text{ J} = \boxed{4.2 \times 10^2\text{ J needed}}$

E2.1(b) The physical definition of work is $dw = -F\,dz$ [2.4]

In a gravitational field the force is the weight of the object, which is $F = mg$

If g is constant over the distance the mass moves, dw may be intergrated to give the total work

$$w = -\int_{z_i}^{z_f} F\,dz = -\int_{z_i}^{z_f} mg\,dz = -mg(z_f - z_i) = -mgh \quad \text{where} \quad h = (z_f - z_i)$$

$$w = -(0.120\,\text{kg}) \times (9.81\,\text{m s}^{-2}) \times (50\,\text{m}) = -59\,\text{J} = \boxed{59\text{ J needed}}$$

Solution 6.05

n/a	n/a	n/a

E2.10(a) $w = -nRT\,\ln\frac{V_f}{V_i}$ [2.13] $V_f = \frac{1}{3}V_i$

$nRT = \boxed{(5.20 \times 10^{-3}\text{ mol})} \times (8.314\,\text{J K}^{-1}\,\text{mol}^{-1}) \times (260\,\text{K}) = 1.12\bar{4} \times 10^2\,\text{J}$

$w = -(1.12\bar{4} \times 10^2\,\text{J}) \times \ln\frac{1}{3} = \boxed{+123\,\text{J}}$

Solution 6.06

n/a	2.7	2.7

E2.7(a)

The chemical reaction that occurs is

$$Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq), \quad M(Mg) = 24.31\ g\ mol^{-1}$$

Work is done against the atmosphere by the expansion of the hydrogen gas produced in the reaction.

$$w = -p_{ex}\Delta V\ [2.10]$$

$$V_i = 0,\ V_f = \frac{nRT}{p_f},\ p_f = p_{ex} \qquad w = -p_{ex}(V_f - V_i) = (-p_{ex}) \times \frac{nRT}{p_{ex}} = -nRT$$

$$n = \frac{15\ g}{24.31\ g\ mol^{-1}} = 0.61\overline{7}\ mol, \quad RT = 2.479\ kJ\ mol^{-1}$$

Hence, $w = (-0.61\overline{7}\ mol) \times (2.479\ kJ\ mol^{-1}) = \boxed{-1.5\ kJ}$

E2.7(b) The reaction is

$$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$$

so it liberates 1 mol of $H_2(g)$ for every 1 mol Zn used. Work at constant pressure is

$$w = -p_{ex}\Delta V = -pV_{gas} = -nRT$$

$$= -\left(\frac{5.0\ g}{65.4\ g\ mol^{-1}}\right) \times \left(8.3145\ J\ K^{-1} mol^{-1}\right) \times (23 + 273)\ K = \boxed{-188\ J}$$