# PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part C, 15 August 2003, 09:00 - 12:00

C1. Consider scattering in three dimensions off a spherical square well or "top-hat" potential $V(r)$, which may be written as

$$V(r) = \begin{cases} V_0 & \text{for} \quad r < a\,, \\ 0 & \text{for} \quad r \geq a\,. \end{cases}$$

(a) (4 points) In the Born approximation, what is the differential cross section $\frac{d\sigma}{d\Omega}$ for scattering from this potential? Do attractive and repulsive potentials behave differently?

(b) (4 points) What is the total cross section $\sigma$ in the limit $ka \to 0$? For what $V_0$ does $\sigma$ exceed the "geometric" cross section $\sigma = \pi a^2$?

(c) (2 points) What is the total cross section $\sigma$ as a function of $k$?

C2. A capacitor is formed by a rigid metal sphere of radius $a$ and a spherical shell of radius $b_0$ made of a conductor. The shell surrounds the sphere in a concentric manner.

(a) (4 points) What is the capacitance $C_0$ of this capacitor?

(b) (6 points) Suppose the spherical shell is elastic, so that a uniform radial force $F$ on it will cause the radius $b_0$ to become $b_0 + \frac{F}{k}$, where $k$ is a constant. When voltage $V$ is applied between the shell and the sphere, give the radius $b$ of the shell to the lowest order beyond $b_0$. For clarity, the expression may contain only $a$, $b_0$, $C_0$, and $V$, and no $\epsilon_0$ is allowed to appear.

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C3. The *Otto Cycle* is a highly idealized engine. Assume the working substance of this engine is an ideal gas, and this cycle is sketched on the $P$ *vs.* $V$ diagram as shown below. Steps $(1 \rightarrow 2)$ and $(3 \rightarrow 4)$ are adiabatic processes, while steps $(2 \rightarrow 3)$ and $(4 \rightarrow 1)$ are isochoric processes.

(a) (5 points) Calculate the efficiency of this cycle if $\gamma = 1.4$ and the compression ratio $V_i/V_f = 10$.

(b) (5 points) Calculate the work done on the gas in the compression process $(1 \rightarrow 2)$, assuming $V_i = 2$ liters and $P_i = 1$ bar.