**1.** The saturation vapour pressure (SVP) of water is the pressure at which the water in two different phases is in *equilibrium*, i.e. as many molecules are leaving one phase as are entering it (per unit time), e.g. liquid water $\leftrightarrow$ gaseous water vapour, or gaseous water vapour $\leftrightarrow$ solid crystals.

For water vapour in air (an ideal gas), the SVP is expressed as a *partial pressure* ($P_{H_2O}$). Partial pressure is the pressure of any consituent in the gas, e.g. the total pressure would be

$$P = P_{H_2O} + P_{dry\ air} = P_{H_2O} + P_{N_2} + P_{O_2} + P_{Ar} \qquad (1)$$

The SVP can be described by ($P$ in Pascals and $T$ in $^\circ C$)

$$P_{H_2O}(SVP) = 610.78 * exp\left(\frac{17.2694 * T}{T + 238.3}\right) \qquad vapour \leftrightarrow liquid \quad (2)$$

$$P_{H_2O}(SVP) = exp\left(-\frac{6140.4}{(T + 273)} + 28.916\right) \qquad vapour \leftrightarrow solid \quad (3)$$

so for rain, Eqn. 2 applies and for snow, Eqn. 3 applies.

Finally, the *relative humidity*, $RH$, is the ratio of the actual partial pressure of $H_2O$ to the SVP, usually expressed as a percentage.

**(a)** Plot a graph of the SVP from -40 $^\circ C$ to +40 $^\circ C$. Ensure that the plot is well-labeled.

**(b)** At 11:00 p.m. on Jan. 14, 2019, Kingston's weather was: $P$ = 102.80 kPa, $RH = 78\%$, $T = -11\ ^\circ C$. Calculate:
(i) The SVP in Pa.
(ii) $P_{H_2O}$.
(iii) $P_{N_2}$, $P_{O_2}$,$P_{Ar}$, and $P_{dry\ air}$.
(iv) The molar fraction for each constituent (i.e. what fraction of the total number of moles is $H_2O$, $N_2$, $O_2$, and $Ar$).
(v) The mean molecular weight, $\mu$, of this moist air.

**(c)** Repeat part (b) for 12:00 noon on Jul. 28, 2018 when $P$ = 101.47 kPa, $RH = 63\%$, $T = 25\ ^\circ C$.

**(d)** Compare the mean molecular weights of dry air, warm moist air and cold moist air. (use words!)