To determine the heat capacity of

(i) Argon Ar (2 points)

Argon is a monatomic gas, thus the heat capacity can be estimated to be

$$\boxed{c_v \approx \frac{3}{2}R}$$

Assuming Argon behaves as ideal gas,

$$c_p = c_v + R = 2.5R$$

Determine the relative magnitude of the three modes of kinetic energy:

Translational mode = 1.5R

Monatomic gases do not display vibrational or rotational kinetic energy.

Vibrational mode = 0 (monatomic)

Rotational mode = 0 (monatomic)

(ii) Oxygen O_2 (4 points)

$$\frac{c_p}{R} = A + BT + CT^2 + DT^{-2} + ET^3 \qquad (1)$$

Using Table A.2.2 in Appendix A.2

A	B	C	D	E
3.639	0.506e-3	-	-0.227e5	-

Substituting the values into Equation (1)

$$c_p = 3.54R$$

Assuming that Oxygen behaves as an ideal gas at 300K

$$c_v = c_p - R = 2.54R$$

Determine the relative magnitude of the three modes of kinetic energy:

Translational mode = 1.5R

As Oxygen is a linear molecule, the rotational mode contribution is

Rotational mode = R (Linear molecule)

At 300 K, the vibrational contribution goes to zero,

Vibrational mode ≈ 0 (or 0.04R) (Low Temperature)

(iii)Ammonia NH_3 (4 points)

Using Table A.2.2 in Appendix A.2

A	B	C	D	E
3.5778	3.02e-3	-	-0.186e5	-

Substituting the values into Equation (1)

$$c_p = 4.3R$$

Assuming Ammonia behaves as an ideal gas at 300 K

$$c_v = c_p - R = 3.3R$$

Determine the relative magnitude of the three modes of kinetic energy:

Translational mode = 1.5R

As Ammonia is a non-linear molecule, the rotational mode contribution is

Rotation mode = 1.5R (Non-linear molecule)

At 300 K, the vibrational contribution goes to zero,

Vibrational mode ≈ 0 (or 0.3R) (Low Temperature)

Note:

The sum of the three models of kinetic energy (translational, vibrational, rotational) may not be exactly equal to the heat capacity c_v calculated. This may be due to

(i) Deviation from ideal gas behavior
(ii) Slight differences between the exact values of the three modes of kinetic energy and the theoretical values given in the text.