EXAM 3

Name:

Your code is: AAAAAA

Put your name here:

Keep this exam CLOSED until advised by the instructor.

60 minute long closed book exam.

Fill out the bubble sheet: last name, first initial, student number, section number and code.

A two-sided 8.5 by 11 handwritten help sheet is allowed.

When done, hand in your test and your bubble sheet.

Thank you and good luck!

Possibly useful constants:
- \( g = 9.81 \text{ m/s}^2 \)
- \( G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2 \)
- \( \sigma = 5.67 \times 10^{-8} \text{ W/(m}^2\text{K}^4) \)
- \( R = 0.0821 \text{ L}^\ast \text{atm}/(\text{mol}^\ast \text{K}) = 8.31 \text{ J/(mol}^\ast \text{K}) \)
- density of fresh water = 1000 kg/m\(^3\)

Possibly useful Moments of Inertia:
- Solid homogeneous sphere: \( I_{\text{CM}} = (2/5)MR^2 \)
- Thin spherical shell: \( I_{\text{CM}} = (2/3)MR^2 \)
- Thin uniform rod, axis perpendicular to length: \( I_{\text{CM}} = (1/12)ML^2 \)
- Solid homogeneous cylinder or disk, axis through center of mass and parallel to length: \( I_{\text{CM}} = (1/2)MR^2 \)

Useful information for Geometry:
- Volume of a sphere: \( V = (4/3)\pi r^3 \)
- Volume of a cylinder: \( V = \pi r^2h \)

Latent Heats and Phase Change Temperatures of some Materials (at atmospheric pressure)

<table>
<thead>
<tr>
<th>Material</th>
<th>( T_f ) (K)</th>
<th>( L_f ) (J/g)</th>
<th>( T_v ) (K)</th>
<th>( L_v ) (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>159</td>
<td>100</td>
<td>351</td>
<td>850</td>
</tr>
<tr>
<td>Copper</td>
<td>1356</td>
<td>207</td>
<td>2868</td>
<td>4730</td>
</tr>
<tr>
<td>Gold</td>
<td>1336</td>
<td>64.5</td>
<td>2933</td>
<td>1580</td>
</tr>
<tr>
<td>Helium</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>14</td>
<td>58.0</td>
<td>20</td>
<td>455</td>
</tr>
<tr>
<td>Lead</td>
<td>601</td>
<td>23.2</td>
<td>2017</td>
<td>858</td>
</tr>
<tr>
<td>Mercury</td>
<td>234</td>
<td>11.4</td>
<td>630</td>
<td>296</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>63</td>
<td>26</td>
<td>77</td>
<td>200</td>
</tr>
<tr>
<td>Oxygen</td>
<td>54</td>
<td>13.9</td>
<td>90</td>
<td>213</td>
</tr>
<tr>
<td>Silver</td>
<td>1235</td>
<td>105</td>
<td>2323</td>
<td>2336</td>
</tr>
<tr>
<td>Tungsten</td>
<td>3783</td>
<td>180</td>
<td>6170</td>
<td>4820</td>
</tr>
<tr>
<td>Water</td>
<td>273</td>
<td>333</td>
<td>373</td>
<td>2263</td>
</tr>
</tbody>
</table>

Specific Heats of some Materials (at room temperature and atmospheric pressure unless otherwise noted)

<table>
<thead>
<tr>
<th>Material</th>
<th>( c ) [J/kg·C]</th>
<th>( c ) [kcal/kg·C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (at 50 ·C)</td>
<td>1050</td>
<td>0.25</td>
</tr>
<tr>
<td>Alcohol</td>
<td>2430</td>
<td>0.58</td>
</tr>
<tr>
<td>Aluminum</td>
<td>920</td>
<td>0.22</td>
</tr>
<tr>
<td>Copper</td>
<td>390</td>
<td>0.093</td>
</tr>
<tr>
<td>Glass</td>
<td>840</td>
<td>0.20</td>
</tr>
<tr>
<td>Granite</td>
<td>790</td>
<td>0.19</td>
</tr>
<tr>
<td>Ice (at -10 ·C)</td>
<td>2090</td>
<td>0.50</td>
</tr>
<tr>
<td>Iron, Steel</td>
<td>460</td>
<td>0.11</td>
</tr>
<tr>
<td>Lead</td>
<td>130</td>
<td>0.031</td>
</tr>
<tr>
<td>Mercury</td>
<td>140</td>
<td>0.033</td>
</tr>
<tr>
<td>Seawater</td>
<td>3900</td>
<td>0.93</td>
</tr>
<tr>
<td>Silver</td>
<td>240</td>
<td>0.056</td>
</tr>
<tr>
<td>Soil, Dirt</td>
<td>1000</td>
<td>0.24</td>
</tr>
<tr>
<td>Steam (110 ·C)</td>
<td>2010</td>
<td>0.48</td>
</tr>
<tr>
<td>Tungsten</td>
<td>135</td>
<td>0.032</td>
</tr>
<tr>
<td>Water</td>
<td>4186</td>
<td>1 exactly</td>
</tr>
<tr>
<td>Wood</td>
<td>1680</td>
<td>0.40</td>
</tr>
</tbody>
</table>
The bimetallic strip above is made of aluminum (coefficient of linear expansion = \(24 \times 10^{-6} \, ^\circ\text{C}^{-1}\)) and silver (coefficient of linear expansion = \(19 \times 10^{-6} \, ^\circ\text{C}^{-1}\)). When this strip is held down at the left end and heated, it will ___________________________.

1. A ☐ bend downward  B ☐ bend upward  C ☐ remain straight, while stretching its length

A constant volume gas thermometer has a pressure of 7940 Pa at 18 °C. What would the pressure be for -99 °C (in Pa)?

2. A ☐ 2.26 \times 10^3  B ☐ 3.28 \times 10^3  C ☐ 4.75 \times 10^3  D ☐ 6.89 \times 10^3  E ☐ 9.99 \times 10^3  F ☐ 1.45 \times 10^4  G ☐ 2.10 \times 10^4  H ☐ 3.04 \times 10^4

Two blocks of metal come into contact with one another. Given the following data:

Block one
Specific heat = 0.111 kcal/(kg °C)
Mass = 0.188 kg
Initial temperature = 17 °C

Block two
Specific heat = 0.19 kcal/(kg °C)
Mass = 0.101 kg
Initial temperature = 71 °C

What is the final temperature (in °C) of the two blocks after they reach equilibrium?

3. A ☐ 34.1  B ☐ 35.9  C ☐ 40.7  D ☐ 42.9  E ☐ 44.0  F ☐ 45.0  G ☐ 54.0  H ☐ 88.0

A metal wire is in thermal contact with two heat reservoirs at both of its ends. Reservoir 1 is at a temperature of 484 K, and reservoir 2 is at a temperature of 323 K. What is the change in entropy (in J/K) of Reservoir 1 arising from the conduction of 1134 J of heat through the wire.

4. A ☐ -3.51  B ☐ -2.34  C ☐ -1.17  D ☐ 0.00  E ☐ 1.17  F ☐ 2.34  G ☐ 3.51  H ☐ 5.85

A massive piston traps a fixed amount of helium gas as shown. After being brought to point (a) the system equilibrates at room temperature. Weight is then added to the piston adiabatically compressing the gas to half of its original volume (b). The internal energy of the gas at "b" is __________ the internal energy of the gas at "a".

5. A ☐ greater than  B ☐ equal to  C ☐ less than

A massive piston traps a fixed amount of helium gas as shown. After being brought to point (a) the system equilibrates at room temperature. The gas is then cooled isobarically compressing the gas to half of its original volume (b). The entropy of the gas at "b" is __________ the entropy of the gas at "a".

6. A ☐ greater than  B ☐ equal to  C ☐ less than
A uniform frictionless pulley is attached to the ceiling, in a gravity field of \(9.81 \text{ m/s}^2\). The mass of the pulley is \(M_p\).

Mass \(M_2\) is greater than mass \(m_1\). The quantities \(T_1\), \(T_2\), \(T_3\) and \(g\) are magnitudes. Select greater than, less than or equal to.

\[ \triangleright T_2 \text{ is } \ldots \text{T}_1. \]

7. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to

\[ \triangleright \text{ If clockwise is defined as the positive direction for rotational motion, then the angular acceleration of the pulley will be } \ldots \text{ zero}. \]

8. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to

A 7.160 kg block is on a ramp and is attached to a 2.487 kg mass by a light string as shown in the diagram below. The string passes over a pulley and the ramp is inclined at an angle of 10 degrees with respect to the horizontal.

If the block on the ramp is moving \(\text{UP}\) the ramp at constant velocity, what is the coefficient of kinetic friction between the block on the ramp and the ramp?

9. \(\bigcirc\) 0.094 \(\bigcirc\) 0.110 \(\bigcirc\) 0.129 \(\bigcirc\) 0.151

\(\bigcirc\) 0.176 \(\bigcirc\) 0.206 \(\bigcirc\) 0.241 \(\bigcirc\) 0.282

A piece of moon rock reads 4.095 N on a scale when in air, but 0.891 N in a fluid having a density of 730 \(\text{ kg/m}^3\). What is the density of the moon rock in \(\text{ kg/m}^3\)?

10. \(\bigcirc\) 2.24 \(\times\) 10^2 \(\bigcirc\) 2.98 \(\times\) 10^2 \(\bigcirc\) 3.97 \(\times\) 10^3

\(\bigcirc\) 5.27 \(\times\) 10^2 \(\bigcirc\) 7.01 \(\times\) 10^2 \(\bigcirc\) 9.33 \(\times\) 10^2

\(\bigcirc\) 1.24 \(\times\) 10^3 \(\bigcirc\) 1.65 \(\times\) 10^3

The side view of a pipe is shown. The pipe diameter increases and then remains constant. \(P_i\) is the pressure, and \(v_i\) is the speed of a non-viscous incompressible fluid, at locations \(i = 1, 2, 3\).

\[ \triangleright v_2 \text{ is } \ldots v_3. \]

11. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to

\[ \triangleright v_1 \text{ is } \ldots v_2. \]

12. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to

\[ \triangleright P_2 \text{ is } \ldots P_1. \]

13. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to

\[ \triangleright P_2 \text{ is } \ldots P_3. \]

14. \(\bigcirc\) Greater than \(\bigcirc\) Less than \(\bigcirc\) Equal to
An ideal heat engine absorbs 85.2 kJ of heat and exhausts 70.4 kJ of heat in each cycle. What is the efficiency of the engine?

\[ \text{Efficiency} = \frac{\text{Heat in} - \text{Heat out}}{\text{Heat in}} \]

Options:
- A. $2.71 \times 10^{-2}$
- B. $3.93 \times 10^{-2}$
- C. $5.70 \times 10^{-2}$
- D. $8.26 \times 10^{-2}$
- E. $1.20 \times 10^{-1}$
- F. $1.74 \times 10^{-1}$
- G. $2.52 \times 10^{-1}$
- H. $3.65 \times 10^{-1}$

How much work is done in a cycle? (in kJ)

\[ \text{Work} = \pi a^2 p \]

Options:
- A. 7.04
- B. $1.02 \times 10^3$
- C. $1.48 \times 10^1$
- D. $2.15 \times 10^1$
- E. $3.11 \times 10^1$
- F. $4.51 \times 10^1$
- G. $6.54 \times 10^1$
- H. $9.49 \times 10^1$

Consider the hydraulic system shown above. A force of 500 N is applied as shown on the piston to the left which has a diameter of $a=2$ cm. The piston on the right has a diameter $b=7$ cm. What weight $W$ (in N) can be lifted with this force? (Ignore friction and the weights of the piston)

\[ \text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{Force}}{\pi a^2} \]

Options:
- A. 3757
- B. 4245
- C. 4797
- D. 5420
- E. 6125
- F. 6921
- G. 7821
- H. 8838