Exam iEE 8-4-2014 (1)

(1) (a)

(1) → (2) adiabatic compression, liquid

(2) → (3) expansion, approximately isobaric, phase transition $l \to v$

4 (3) → (4) adiabatic expansion, vapour + initial phase transition $v \to l$

(4) → (1) isothermal "compression", ~~p~~ full phase transition to liquid

(b) principal: 2 $\eta = \frac{\text{Work done}}{\text{heat invested}} = \frac{W_t - W_p}{Q_H} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}$

4)

$Q_L = (S_4 - S_1) \cdot T_L$

2

$Q_H = \int_2^3 \cancel{S\,dt}\ T\,ds$ ~~m~~ $\rightarrow \eta = 1 - \frac{(S_4 - S_1)\,T_L}{\int_2^3 \cancel{S\,dt}\ T\,ds}$

(c) approximation $\int_2^3 \cancel{S\,dt}\ \cancel{dt}\ T\,ds \approx (S_3 - S_2)\,T_H$ 1 Path of phase transition is much longer than the other two. And even better, we overestimate the first part this way, but underestimate the last. 1

3

(d) 2 These trajectories are not adiabatic anymore

(e) $\eta = 1 - \frac{T_L}{T_H}$ $T_L = 115\,^\circ C = 388\,K$

3

1 → $T_H = T_3 - \approx 100 = 510\,^\circ C = 783\,K$

1 $\eta = 50.4\,\%$

from figure 3 we read $T_H = 400\,^\circ C = 673\,K$, $T_L = 130\,^\circ C = 403\,K$

1 $\eta = 40\,\%$

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(2) (a) $a_a = \frac{(100-24)}{340} = 0.2235...$

3

$t_a = \frac{185}{340} = 0.5441...$

$a_s = \frac{24}{185} = 0.1297...$

(b) sensible heat : actual heat transported upwards by "warm" air

3 latent heat: the heat of condensation transported up in the form of water vapour contained in rising air (which can potentially condensate) $C = 104$ W/m²

(c) 1 10 - 25 μm

(d) 1 $t_a' = 0.7 \rightarrow$ atmospheric window $= 39.8$ W/m²

(e) 2 $\sigma T_s^4 = 398 \rightarrow T_s = 289.45$ K

(f) 2 i $\sigma T_a^4 = 342 \rightarrow T_a = 278.68$ K

ii $\sigma T_a^4 = (239 - 40) = 199 - T_a = 243.398$ K

(g) temperature at low and high altitudes, respectively.

3 The low altitude air represents the air from which thermal infrared makes it back to the surface, ~~the ht~~ whereas only radiation from high up in the atmosphere finally makes it to outer space.

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3

(a) this reaction is the "best accessible", that is the lowest energy needed
2 to get it going.

(b) ^3T is formed through a nuclear reaction with ^6Li and neutrons
2

(c) ^2D 1.1 MeV/nucleon ×2 2.2
^3T 2.8 MeV/nucleon ×3 8.4

4

^4He 7.1 MeV/nucleon 28.4 MeV
→ n° —

17.8 MeV per reaction

(d) The plasma gets heated by this binding energy, heat transferred to the walls,
3 and through heat exchangers brought to an external steam turbine

4
3 (a) $E = \frac{1}{2} \partial m \, u^2$ $\partial m = \rho . A . u . \Delta t$ 1

$\rightarrow$ 1 $\frac{E}{A . \Delta t} = \frac{1}{2} \rho u^3$ 1

NB Students performed very badly! Decided to compute marks with max points = 10 here and weight 5

(b) The area from which wind energy is harvested is A_{IN}, not A. And A_{IN}/A depends on the velocity ratio u/U_{IN}

2

Correct efficiency $\eta = \left(1 - \left(\frac{U_{OUT}}{U_{IN}}\right)^2\right) \cdot \frac{A_{IN}}{A} = \left(1 - \left(\frac{U_{OUT}}{U_{IN}}\right)^2\right) \cdot \frac{u}{U_{IN}}$

(c) work = Force × distance
= mass × acceleration × distance

1 $= \partial m \times \frac{U_{OUT} - U_{IN}}{\Delta t} \times u \Delta t$

and work = decrease of kinetic energy:

1 $$\tfrac{1}{2}J_m U_{IN}^2 - \tfrac{1}{2}J_m U_{OUT}^2 = -J_m \times \frac{U_{OUT}-U_{IN}}{\Delta t} \times u\Delta t$$

4)

$$\tfrac{1}{2}\cancel{(U_{IN}-U_{OUT})}(U_{IN}+U_{OUT}) = -u\cdot\cancel{(U_{OUT}-U_{IN})}$$

1 $$u = \frac{U_{IN}+U_{OUT}}{2}$$

(d) $$\eta = \left(1-\left(\frac{U_{OUT}}{U_{IN}}\right)^2\right)\cdot\frac{u}{U_{IN}} \quad \leftarrow U_{OUT} = 2u - U_{IN}$$

(4) — if not found in (c) start with anything else

$$= \left(1-\left(\frac{2u-U_{IN}}{U_{IN}}\right)^2\right)\frac{u}{U_{IN}}$$

work towards an expression with u/U_{IN} (of the like)

$$= \text{[illegible]}\left(1-\left(\frac{2u}{U_{IN}}-1\right)^2\right)\frac{u}{U_{IN}}$$

$$= \left(\frac{4u}{U_{IN}} - 4\left(\frac{u}{U_{IN}}\right)^2\right)\frac{u}{U_{IN}}$$

2 $$= 4\left[\left(\frac{u}{U_{IN}}\right)^2 - \left(\frac{u}{U_{IN}}\right)^3\right] = 4(\alpha^2-\alpha^3)$$

maximum 1 $$\frac{\partial\eta}{\partial\frac{u}{U_{IN}}} = 0 \qquad 8\alpha - 12\alpha^2 = 0$$

$$8 = 12\alpha \qquad \alpha = \frac{2}{3} \rightarrow u = \frac{2}{3}U_{IN}$$

1 $$\rightarrow \eta = 4\left(\left(\tfrac{2}{3}\right)^2 - \left(\tfrac{2}{3}\right)^3\right) = \frac{16}{27}$$

Geo-Energy Question - Answers

Below you find 10 statements; some are true, some are false.

Please indicate for each statement whether it is true or false.

The concept of 'accomodation space' in stratigraphy is determined by climate 1 false

When a sourcerock is buried, it will first produce gas and then, at greater depth, oil will be generated 2 false

The compressibility factor Z is independent on the type of gas 3 false

Gypsum is the first mineral which precipitates when a sea or salt lake dries out through evaporation 4 true

Fluvial point bars have a limited lateral continuity 5 true

Subsidence and sea-level rise have an opposite effect on marine sedimentation 6 false

A compressional subsurface stress field generates reverse faulting 7 true

Reflection seismic data yield higher resolution subsurface images than gravity data 8 true

Gas hydrates represent the largest fossil fuel resources on the planet 9 true

. One barrel-of-oil-equivalent (boe) is approximately equal to 1 m^3 of gas at standard conditions 10 false