Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Mark Schemes

Q1.

(a)

Process 1	Process 2	
constant pressure	isothermal	
constant volume	adiabatic	
constant pressure	adiabatic	
constant volume	isothermal	✔

*Tick **only** in cell indicated.*

1

(b) Attempt to apply $p_1V_1 = p_2V_2$ or pV = constant ✔
$(1.00 \times 10^{-4} + 2.80 \times 10^{-4} - V)\ 1.01 \times 10^5 =$
$1.83 \times 10^5 \times (2.80 \times 10^{-4} - V)$ ✔
Leading to $V = 1.57 \times 10^{-4}$ m^3 ✔

1st mark for equating pV before to pV after plunger pushed in - in words or symbols or numbers

*2nd mark for correct substitution in **either** p_1V_1 **or** p_2V_2 **or** both*

3rd mark for answer

3

(c) steeper curve ✔
vertical line ✔
(as shown alongside)

Allow vertical line that does not come right down to end of isothermal compression line

2

(d) (In isothermal process) (for internal energy to remain constant) energy transfer must take place ✔
If change is slow there is enough/sufficient time (for energy transfer) ✔

Statements showing the First Law applied to an isothermal compression in symbols are not enough unless symbols are explained.

2

[8]

Q2.

(a) Work done ✔

(b) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist marking this question.**

Mark	Criteria
6	There is a response to all 3 bullet points in the question. There is a good understanding of the function of a flywheel, and why the torque varies markedly in a diesel engine. Student can relate the answer to the two graphs. Includes 6 or more answer points from the list alongside
5	There is a response to all 3 bullet points in the question covering 6 answer points. Answers will not be as confident or detailed as for 6 marks, or answers may not be expressed using scientific terminology.
4	The student gives five or more answer points covering at least two of the bullet points.
3	At least four pertinent statements. They may show little understanding of the electric motor but should be able to give some reasons why a diesel engine needs a flywheel.
2	Two or three pertinent statements taken from the list of likely answer points.
1	One pertinent statement.
0	No sensible statements made.

Other sensible and applicable points can be accepted in lieu of any of those alongside.

Likely answer points:

<u>1st bullet</u>

1. *Electric motor's constant torque means smooth motion/doesn't need smoothing/doesn't need a flywheel*
2. *motor's output torque matches the described load*

<u>2nd bullet</u>

3. *relates force/pressure on piston to torque*
4. *force on piston varies over one cycle (as pressure in cylinder varies)*
5. *Torque = Fr and effective r varies as crank rotates*
6. *-ve torque: when work is being done on (the gas in) the engine (during induction, comp, exhaust strokes)*
7. *Zero torque when con rod and crank are in line/at top and bottom dead centres*
8. *This happens at crank angles which are multiples of π*

<u>3rd bullet</u>

9. *Diesel engine's (varying torque) will give uneven/jerky motion/cause stalling*

10. *Flywheel acts as energy store*
11. *Flywheel absorbs energy on power/expansion stroke*
12. *and gives up energy on other parts of cycle*
13. *Flywheel speeds up on expansion stroke*
14. *and slows down during other strokes.*
15. *The greater the M of I of flywheel, the smoother the motion*
16. *If no flywheel engine will stall/become very uneven/jerky*
17. *The greater the M of I of flywheel, the longer engine will take to speed up, slow down/stop*
18. *Because machine has low M of I it will not be able to store energy itself or smooth the motion.*

6

[7]

Q3.

(a) 2.9 rev s^{-1} equivalent = $2\pi \times 2.9$ rad s^{-1} = 8.2 rad s^{-1}

OR $I = 2 E_k / \omega^2$

OR correct substitution in $E_k = ½ I \omega^2$ ✔

leading to $I = 6.2 \times 10^{-2}$ kg m^2 ✔

1st mark for correct conversion rev s^{-1} OR rearranging energy equation in terms of I OR correct substitution in $E_k = ½ I \omega^2$

2nd mark for correct answer.

Do not allow final answer to 1 sig fig e.g. 0.06

2

(b) I depends on how mass is distributed about axis (of rotation)

For arms, screw and punch same mass is/point masses are closer to axis than the steel balls (making M of I lower) ✔

I depends on r^2 so I changes greatly for small change in in r ✔

Allow 'other parts' or 'other components' if it is clear this means screw, punch and arms

2

(c) $\alpha = \frac{2 \times \pi \times (0 - 2.9)}{0.089}$ = –205 rad s^{-2} ✔

Attempt to use $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ or $\theta = \omega 1t + ½ \alpha t^2$

or $\theta = ½ (\omega_1 + \omega_2)t$ ✔

giving θ = 0.81 rad ✔

Condone missing sign or α given as positive Accept 200 rad s^{-2}

If α positive, 2nd mark for attempt to use

$\omega_2^2 = \omega_1^2 - 2\alpha\theta$ or $\theta = \omega_1 t - ½ \alpha t^2$

or $\theta = ½(\omega_1 + \omega_2)t$ ✔

ECF for value of ω used in (a)

3

(d) (I = 2 mr^2 and E_k = ½ $I\,\omega 2$)

Increasing y by 15% gives new I = 1.15^2 × original I (or 1.32) ✔

Increasing R by 15% increases I by 1.15^3 (or 1.52) ✔

Second option gives greater increase in I, and E_k also increased (by same ratio). ✔

Accept answers without calculation:

I prop to y^2 ✔

I prop to R^3 ✔

For <u>same</u> % increase in y or R, I and hence E_k increases more by increasing R ✔

Note: $E_k = m\,r^2\,\omega^2 = 4/3\,\pi\,R^3\,\rho\,r^2\,\omega^2$ for each ball

3

(e) ✔ against N m s

1

[11]