CLAIMS

1. A process for producing phenol and/or cyclohexanone, said process comprising:

(a) contacting cyclohexylbenzene with an oxygen-containing gas under conditions effective to produce an oxidation effluent containing cyclohexylbenzene hydroperoxide;

(b) contacting at least part of said oxidation effluent containing cyclohexylbenzene hydroperoxide with a cleavage catalyst under conditions effective to produce a cleavage effluent containing phenol and cyclohexanone;

wherein at least one of said oxidation effluent and said cleavage effluent contains at least one by-product selected from phenylcyclohexanols and phenylcyclohexanones;

(c) contacting at least part of said at least one effluent containing said at least one by-product with hydrogen in the presence of a bifunctional catalyst comprising (i) an acid dehydration component comprising a molecular sieve of the MCM-22 family and (ii) a hydrogenating metal component ~~a dehydration catalyst~~ under conditions effective to convert at least part of said by-product to ~~phenylcyclohexene; and~~

~~(d) contacting at least part of said phenylcyclohexene with hydrogen under conditions effective to convert at least part of said phenylcyclohexene to~~ cyclohexylbenzene.

~~2. The process of claim 1, wherein said contacting steps (c) and (d) are conducted in the same reaction zone.~~

~~3. The process of claim 2, wherein said contacting steps (c) and (d) are conducted in the presence of a bifunctional catalyst comprising an acid dehydration component and a hydrogenating metal component.~~

~~4. The process of claim 3, wherein said acid dehydration component comprises a molecular sieve.~~

~~5. The process of claim 4, wherein said molecular sieve comprises a molecular sieve of the MCM-22 family.~~

~~6.~~2. The process of ~~any one of claims 3 to 5~~ claim 1, wherein said hydrogenating metal component comprises at least one metal selected from Groups 6 to 12 of the Periodic Table of Elements.

~~7.~~3. The process of ~~any one of claims 3 to 6~~ claim 1 or claim 2, wherein said hydrogenating metal component comprises palladium.

~~8.~~4. The process of any one of claims ~~3~~ 1 to ~~7~~ 3, wherein said bifunctional catalyst comprises from 0.1 wt% to 1.0 wt % of said hydrogenating metal component.

~~9.~~5. The process of any one of the preceding claims, wherein said conditions in said contacting ~~steps~~ step (c) ~~and (d)~~ comprise a temperature of 25°C to 200°C.

~~10.~~6. The process of any one of the preceding claims, wherein said conditions in said contacting step ~~(d)~~ (c) comprise a hydrogen partial pressure of 15 kPa to 1000 kPa.

~~11.~~7. The process of any one of the preceding claims, wherein said at least one by-product comprises at least one of 2-phenyl-1-cyclohexanol, 3-phenyl-1-cyclohexanol, 4-phenyl-1-cyclohexanol, 2-phenylcyclohexanone, 3-phenylcyclohexanone, and 4-phenylyclohexanone.

~~12.~~8. The process of any one of the preceding claims, further comprising:

(e) separating at least part of said cleavage effluent from said contacting step (b) into a first fraction containing phenol and cyclohexanone and a second fraction containing said at least one by-product; and

(f) supplying said second fraction to said contacting step (c).

~~13.~~9. The process of claim ~~12~~ 8, wherein said separating step (e) is effected in a first distillation column.

~~14.~~10. The process of claim ~~13~~ 9, wherein said second fraction is removed as a side stream from said first distillation column.

~~15.~~11. The process of claim ~~13~~ 9 or claim ~~14~~ 10, wherein at least part of the product produced in said contacting step ~~(d)~~ © is fed back to said first distillation column.

~~16.~~12. The process of any one of claims ~~12~~ 8 to ~~15~~ 11, wherein said cleavage catalyst in said contacting step (b) comprises sulfuric acid and said process further comprises:

(g) neutralizing a residual sulfuric acid in said cleavage effluent with amines to produce amine salts in said cleavage effluent; and

(h) removing at least part of said amine salts prior to said separating step (e).

~~17.~~13. The process of claim ~~16~~ 12, wherein said removing step (h) is effected in a second distillation column.

~~18.~~14. The process of any one of the preceding claims, further comprising:

(i) recycling at least part of said cyclohexylbenzene produced in said contacting step ~~(d)~~ (c) to said contacting step (a).

~~19.~~15. The process of any one of the preceding claims, wherein said contacting step (a) is effected in the presence of a catalyst.

~~20.~~16. The process of any one of the preceding claims, wherein said contacting step (a) is effected in the presence of a cyclic imide catalyst.

~~21.~~17. The process of any one of the preceding claims, wherein said cyclohexylbenzene is produced by alkylation of benzene with cyclohexene.

~~22.~~18. The process of any one of the preceding claims, wherein said cyclohexylbenzene is produced by a reaction of benzene with hydrogen in the

presence of a hydroalkylation catalyst.

~~23.~~19. A process for producing phenol and/or cyclohexanone, said process comprising:

(I) contacting benzene with hydrogen in the presence of a hydroalkylation catalyst under a hydroalkylation condition effective to produce a hydroalkylation effluent comprising cyclohexylbenzene;

(II) contacting at least part of said cyclohexylbenzene in said hydroalkylation effluent with an oxygen-containing gas under conditions effective to produce an oxidation effluent containing cyclohexylbenzene hydroperoxide;

(III) contacting at least part of said oxidation effluent containing cyclohexylbenzene hydroperoxide with a cleavage catalyst under conditions effective to produce a cleavage effluent containing phenol and cyclohexanone,

wherein at least one of said oxidation effluent and said cleavage effluent contains at least one by-product selected from phenylcyclohexanols and phenylcyclohexanones;

(IV) contacting at least part of said at least one effluent containing said at least one by-product with hydrogen in the presence of a bifunctional catalyst comprising (i) an acid dehydration component comprising a molecular sieve of the MCM-22 family and (ii) a hydrogenating metal component ~~a dehydration catalyst~~ under conditions effective to convert at least part of said by-product to ~~phenylcyclohexene; and~~

~~(V) contacting at least part of said phenylcyclohexene with hydrogen under conditions effective to convert at least part of said phenylcyclohexene to~~ cyclohexylbenzene.

~~24.~~20. The process of claim ~~23~~ 19, further comprising:

(VI) recycling at least part of said cyclohexylbenzene produced in step (V) to said contacting step (II).

~~25.~~21. The process of claim ~~23~~ 19 or claim ~~24~~ 20, further comprising:

(VII) separating at least part of said cleavage effluent produced in said contacting step (III) into a first fraction containing phenol and cyclohexanone and a

second fraction containing said at least one by-product; and

(VIII) supplying at least part of said second fraction to said contacting step (IV).